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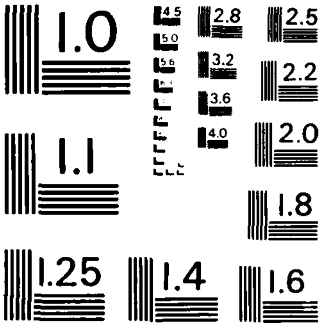

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THE OPTICAL SPECTRA OF AEROSOLS

Final Technical Report

by

F. Borghese

February 1985

United States Army

EUROPEAN RESEARCH OFFICE OF THE U.S. ARMY

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The macroscopic optical constants of an aerosol of model nonspherical particles are calculated. The effect of chemical reactions on the spectra of the aerosols are taken into account. The computer programs necessary to perform the above mentioned calculations are listed and an user's guide is supplied.

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Introduction

In this Report we describe the work done by the principal investigator (Prof. F.Borghese) and his collaborators (Prof. P.Denti, Prof. G.Toscano and Dr R.Saija) under contract DAJA37-81-C-0895 from October 1981 to November 1984. The whole research has been performed in strict collaboration with Dr O. I. Sindoni, CRDC, Aberdeen P.G., 21010 Md., USA.

In Part A we connect the work done in the years 1979-1981 under Grant DAERO78-G-106, to the work done in the last three years under the present Contract. The work itself is actually described in the papers thus far published or accepeted for publication. A brief account of the problems met in the course of the work as well as a suggestion of possible solutions and sketch of the lines of future progress are also included.

In Part B is described the work done by F.Borghese, P.Denti and R.Saija during their stay at CRDC from August 18th to September 23rd, 1984 under Contract Modification P0004. Essentially the work consists of two modifications of the computer programs for the scattering properties of clusters. The purpose of these modifications is twofold: on one hand they allow the treatment of relatively large clusters; on the other hand they constitute the basis for the calculations of the properties of scatterers in which resonances occur. A description of the programs as well as a guide to the input and output quantities is included.

PART A

In the years from 1979 to 1981, working under Grant DAERO78-G-106, we devised a model scatterer suitable to approximate the eléctromagnetic scattering properties of non-spherical particles . By inspiring to the well known stick-and-ball model of a molecule, we approximate a non-spherical particle as a cluster of spheres. The computation of the scattering properties of such an object do not require a big effort, thank to an addition theorem for vector Helmholtz harmonics(1) formulated by the present authors. As a consequence several calculations on clusters of various geometries proved the model to be computationally sound and able to account for the lack of overall spherical symmetry of some kind of non-spherical particles. A detailed account of the model as well as the use of the Group Theory to reduce the size of the computations is contained in the Final Report to Grant DAERO78-G-106, October 1981, as well as in a number of published papers(2-4).

In the years from 1981 to 1984, i.e. under the present Contract, we were able to take full advantage of the peculiarities of the cluster model in order to connect the scattering properties of individual clusters to the macroscopic optical properties of a dispersion of clusters of random orientation(5). Furthermore, the flexibility of the cluster model allows the calculation of the changes in the macroscopic optical constans of an aerosol, when the clusters change their shape or when more clusters combine together to give scattering objects of different structure. The calculations show that these changes of shape produce quite detectable variations in the

absorption coefficient of the dispersion(6).

These results have been recently presented at the 1st Joint International Conference on Aerosol Research, held in Minneapolis, MN, from September 17th to 21st(6,7). In particular it has been emphasized the rather striking result that for a cluster of given structure and size parameter there exist a wavelength at which it behaves as a spherical particle. This conclusion is confirmed by a number of experimental findings of which we were informed during discussions on the subject.

We want to stress that the approach we used to connect the individual to the collective optical properties is rather elementary as it neglects the effects of multiple scattering among different clusters. As a consequence, our approach is applicable only to low-density dispersions such as atmospheric aerosols but it is unlikely to give reliable results when applied to dense dispersions such as e.g. smokes. We plan to overcome these difficulties by investigating the subject along three lines. First of all we plan to include the statistic of the particles into our formalism, so as to account, on the average, for the effect of multiple scattering and thus make the theory applicable to dispersions of relatively high density. Second, we are going to study the size distribution effect, for it has been shown that the occurrence of some size distributions can affect drastically the macroscopic optical properties of the dispersion.

Third, we will attempt to adapt our theory to the framework of the effective medium theories in order to calculate the effective dielectric constant of the dispersion. We got this idea at the Annual Meeting of Spectroscopy Group of the Gruppo Nazio

nale di Struttura della Materia held in Alghero, Sardinia, where the problem of small clusters has been throughly discussed.

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5. F.Borghese, P.denti, R.Saija, G.Toscano and O.I.Sindoni: Nuovo Cimento 81B, 29 (1984).

6. R.Saija, O.I.Sindoni, G.Toscano, F.Borghese and P.Denti: Nuovo Cimento (in the press).

7. O.I.Sindoni, F.Borghese, P.Denti, R.Saija and G. Toscano: in "Aerosol", Proc. 1st International Aerosol Conference, (B.Y.H.Liu, D.Y.H.Pui and H.J.Fissan eds.) Elsevier, New York 1984, pag.810.

8. R.Saija, O.I.Sindoni, G.Toscano, P.Denti and F.Borghese: in "Aerosol", Proc. 1st International Aerosol Conference, (B.Y.H.Liu, D.Y.H.Pui and H.J.Fissan eds.) Elsevier, New York 1984, pag.817.

The references with an asterisk were published under Grant DAERO-78-G-106 and they are cited for the comodity of the reader.

PART B

This part of the present Report is meant to be a user's guide to our programs for the scattering properties of clusters. Before we go into the description, however, we want to explain why we felt necessary to write two further versions of the programs we used in the past.

Our treatment of the scattering from clusters is based on a multicentered expansions of the scattered field in terms of spherical multipoles. For convergence reasons, as explained in the included literature, this expansion must be carried up to a certain order L_M which, depending on the structure and on the size parameters may be as high as 4 or 5. Now for a given L_M one has to calculate, and invert, matrices with complex elements of order $d_M=2NL_M(L_M+2)$, N being the number of the spheres in the cluster. Therefore, due to the storage limitations on the computer presently available in Messina, and at CRDC too, it is impossible to handle clusters of more than 5 spheres with $L_M = 5$. This is the maximum order that can be handled by the program PRG1 with a core allowance of 4 Mbytes. This limitation has been overcome by rewriting the program without requiring the storage of the intermediate matrices but requiring the storage of two vectors one for the spherical harmonics and another for the Clebsch-Gordan coefficients. This version of the program named here PRG2, allows us to handle relatively big clusters at the cost of multiplying the CPU time by a factor of 4. A second version of the program, he PRG3, do not require either the storage of the vecto C-G coefficients, thus allowing us to handle even big

ster but multiplying the CPU time by a factor of 6 or 7. The capability of the three programs when a core storage of 4 Mbytes is allowed are summarized in Table I.
As can be seen the biggest cluster can be treated only at the cost of neglecting the interactions of order higher than dipole-dipole. In any case this interaction is just that that is commonly included in the calculations of other workers. On the other hand our programs allows us to get information of value on the properties of clusters including as much as 70 spheres. Furthermore these programs allow to treat with great precision the case in which resonances occur, a case in which the multipolar interactions must be included as high to an order as possible.

The formulation and testing of these programs is essentially the work done by F.Borghese, P.Denti and R.Saija during their stay at the CRDC under contract modification P0004.

PRG1

This is the original version of our scattering programs and, as listed, it can handle a cluster of 3 spheres with $L_M=4$. The maximum capability of PRG1 is a cluster of 5 spheres with $L_M=4$. In this case the dimensions of the various matrices and vectors must be carefully checked.

INPUT DESCRIPTION

Refer to DATASET H2OTEST001.

CARD 1 (3A4)

IDATA JDATA KDATA	These quntities identify the DATASET. They can be left blank if desired.

CARD 2 blank

CARD 3 (4I2)

JGO JWMA IWCSS IWCIP	These quantities control the input and output operations of PRG1. Their exact meaning is explained in the comment cards within the programs. Note that if JGO is put equal to 1 for all the groups of data the program runs properly but for that it recomputes matrices whose elements have still valid values.

CARD 4 (5I2)

NSPH	Number of the spheres in the cluster.
LMPO	L_M+1
IHELP	Helicity of the incident wave. Use +1 for right helicity, and -1 for left helicity.
IEXP	This quantity was originally introduced to control the convergency of the multipolar expansions. Set it to 0.
MAXIT	Number of iterations. To be used only when the inverse to the matrix (15) of ref.(2) is to be calculated iteratively.

CARD 5 (3E20.8) (NSPH cards)

RXX(I) RYY(I) RZZ(I)	Cartesian coordinates of the centres of the I-th sphere in the cluster.

CARD 6 (40I2)

IOG(I)	This index specifies the type of the I-th sphere in the cluster. If IOG(I+1)=IOG(I) the program does not recalculate the T-matrices for the I+1-th sphere but take them identical to those of the I-th sphere.

CARD 7 (3E20.8)

ROS(I)	Radius of the I-th sphere.

CARD 8 (2E20.8)

CRI(I)	Complex refractive index of the I-th sphere.

CARD 9 (E20.8,2F10.4)

VK	Magnitude of the wavevector of the incident wave.
THK PHK	Polar angles (in degrees) of the incident wavevector.

CARD 10 (3I5)

INVER	0 the T-matrix of the cluster is inverted iteratively. 1 the T-matrix is inverted by LU factorization.
MODE	0, 1, 2, 3. This parameter provides the equilibration of the T-matrix in four different modes. The value MODE =3 has proved to be the most suitable for dielectric clusters far from resonance.
NPDMST	Maximum dimension of the T-matrix. It <u>must</u> be identical to the dimension of the matrix AM.

CARD 11 (2E20.8)

CI	Mixing factor for the iterative inversion of the T-matrix. The value CI=0.5 ensures good convergence.
TOL	Tolerance of the inverted T-matrix. In practice $T*T^{-1} \leq$ TOL. These quantities need be specified only when INVER=0

CARD 12	(40A4)
NAME	Identifies the output. It can include any alphameric character.

```
                      VS FORTRAN            DATE: 1984 NOV 07        TIME: [illegible]

     OPTIONS IN EFFECT: NOLIST NOMAP NOXREF NOGOSTMT NODECK  SOURCE    TERM   OBJECT FIXED  NOT
         OPT(0) LANGLVL(77) NOFIPS   FLAG(I)  NAME(MAIN   )  LINECOUNT(85)

*....+...1.........2.........3.........4.........5.........6.........7.*....

      SUBROUTINE SMAT
     1          (LMPO,NSPH)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUT3/ RXX(4),RYY(4),RZZ(4),
     1ROS(4),CRI(4),XIL(4),
     2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
     3W(15,2),AI(120),AF(120),AMMO(15),ALMO(15),S(15),NAME(40),ICG(4)
      COMMON/DUM2/GH(64,64),GK(64,64)
      COMMON/DUM5/AM(120,120),BV(120),V(120)
      COMPLEX*16 AM,GH,GK,RM,SM,CRI,XIL,XILI,W,AI,AF,
     1ALMO,AMMO,S,BV,SSMSP,SSESP,TSAS,SAC
      LM=LMPO-1
      NLMM=LMPO*LMPO-1
      NM=NSPH*NLMM
      NST=NM+NM
      IK=1
      L=1
      IL=3
      DO 10 I=1,NM
      SSMSP=RM(L,IK)
      SSESP=SM(L,IK)
      IF(I.LT.IL)GO TO 5
      L=L+1
      IF(L.GT.LM)L=1
      IL=IL+L+L+1
    5 II=I+IK
      IK=I/NLMM+1
      JN=1
      DO 10 J=1,NM
      JJ=J+JN
      JN=J/NLMM+1
      AM(I,J)=GH(II,JJ)*SSMSP
      AM(I,J+NM)=GK(II,JJ)*SSMSP
      AM(I+NM,J)=GK(II,JJ)*SSESP
   10 AM(I+NM,J+NM)=GH(II,JJ)*SSESP
      RETURN
      END

SOURCE STATEMENTS =   32, PROGRAM SIZE =    3072 BYTES, PROGRAM NAME = SMAT     PA

  NO DIAGNOSTICS GENERATED.

COMPILATION  7  ******
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[illegible] LIST NOMAP NOXREF NOGOSTMT NODECK SOURCE TERM OBJECT FIXED NOT
   OPT(0) LANGLVL(77) NOFIPS FLAG(I) NAME(MAIN ) LINECOUNT(85)

*....*...1.........2.........3.........4.........5.........6.........7.*....

      SUBROUTINE CROSSE
     1(LMPO,NS,VK,IHELP,
     2SCASEC,ABSSEC,TOTSEC)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUM3/ RXX(4),RYY(4),RZZ(4),
     1RCS(4),CRI(4),XIL(4),
     2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
     3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IOG(4)
      COMMON/DUM4/GIM(64,16),GLM(64,16),GIP(64,16),GLP(64,16)
      COMPLEX*16 GIP,GLP,AI,AF,W,AMMO,AEMO,AM,AE,GI,GL,SUMM,SUME,
     1CRI,XIL,XILI,RM,SM,S,GIM,GLM,CCCN,CFDET,TSAS,SAC
      DATA PI4/ 12.566370614356/
      NLM=LMPO*LMPO
      NLMM=NLM-1
      NM=NLMM*NS
      NDIM=NM+NM
      CC=.5/(VK*VK)
      CCCN=-(0.D0,1.D0)*(.5*CC/VK)
      IF(IHELP.EQ.-1) GO TO 10
      ISA=1
      JSA=2
      GO TO 12
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
      SUMM=SUMM+AM*GI+AI*GL
   15 SUME=SUME+AM*GL+AI*GI
      AMMO(ILV)=SUMM
   20 AEMO(ILV)=SUME
      DO 25 I=1,NLMM
      AMR=DREAL(AMMO(I))
      AMI=DIMAG(AMMO(I))
      AER=DREAL(AEMO(I))
      AEI=DIMAG(AEMO(I))
      IF(DABS(AMR).LT.1.D-30)AMR=0.D00
      IF(DABS(AMI).LT.1.D-30)AMI=0.D00
      IF(DABS(AER).LT.1.D-30)AER=0.D00
      IF(DABS(AEI).LT.1.D-30)AEI=0.D00
      AMMO(I)=DCMPLX(AMR,AMI)
      AEMO(I)=DCMPLX(AER,AEI)
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
      CFDET=CFDET+DCONJG(W(I,JSA))*(AM-IHELP*AE)
      SUME=SUME+DCONJG(W(I,ISA))*(AM+IHELP*AE)
      SCASEC=CC*DREAL(SUMM)
      TOTSEC=-CC*DREAL(SUME)
      ABSSEC=TOTSEC-SCASEC
      SAC(ISA,ISA)=SUME*CCCN
      SAC(JSA,ISA)=CFDET*CCCN
      RETURN
      END
SOURCE STATEMENTS = 64, PROGRAM SIZE = 5896 BYTES, PROGRAM NAME = CROSSE

  NO DIAGNOSTICS GENERATED.

COMPILATION [illegible] ******
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```
      CMLP =DCLF3(1,L2 ,L2   ,-1,M2+1)
      CMRM=DCLF3(1,L2-1,L2, 1,M2-1)
      CMR =DCLF3(1,L2-1,L2, 0,M2  )
      CMRP=DCLF3(1,L2-1,L2,-1,M2+1)
      CLCR=CL*CR
      C1M=     CLCR   *GM(IT1   ,I2   )
      C1P=     CLCR   *GP(IT1   ,I2   )
      C2M=     CLCR   *GM(IT3   ,I1   )
      C2P=     CLCR   *GP(IT3   ,I1   )
      CM1M=C00
      CM1P=C00
      CM2M=C00
      CM2P=C00
      IF(CML.EQ.C0) GO TO 15
      CMLCR=CML*CR
      CM1M=     CMLCR *GM(ITM1   ,I2   )
      CM1P=     CMLCR *GP(ITM1   ,I2   )
   15 IF(CMR.EQ.C0) GO TO 20
      CLCMR=CL*CMR
      CM2M=     CLCMR *GM(ITM3   ,I1    )
      CM2P=     CLCMR *GP(ITM3   ,I1    )
   20 IF(CLM.EQ.C0.OR.CRM.EQ.C0) GO TO 25
      CLCRM=CLM*CRM
      C1M=C1M+ CLCRM *GM(IT1MC,IT2MC)
      C1P=C1P+ CLCRM *GP(IT1MC,IT2MC)
      C2M=C2M+ CLCRM *GM(IT3MC,IT4MC)
      C2P=C2P+ CLCRM *GP(IT3MC,IT4MC)
   25 IF(CMLM.EQ.C0.OR.CRM.EQ.C0) GO TO 30
      CMLCRM=CMLM*CRM
      CM1M=CM1M+ CMLCRM*GM(ITM1MC,IT2MC)
      CM1P=CM1P+CMLCRM*GP(ITM1MC,IT2MC)
   30 IF(CLM.EQ.C0.OR.CMRM.EQ.C0) GO TO 35
      CLCMRM=CLM*CMRM
      CM2M=CM2M+CLCMRM*GM(ITM3MC,IT4MC)
      CM2P=CM2P+CLCMRM*GP(ITM3MC,IT4MC)
   35 IF(CLP.EQ.C0.OR.CRP.EQ.C0) GO TO 40
      CLCRP=CLP*CRP
      C1M=C1M+ CLCRP *GM(IT1PC,IT2PC)
      C1P=C1P+ CLCRP *GP(IT1PC,IT2PC)
      C2M=C2M+ CLCRP *GM(IT3PC,IT4PC)
      C2P=C2P+ CLCRP *GP(IT3PC,IT4PC)
   40 IF(CMLP.EQ.C0.OR.CRP.EQ.C0) GO TO 45
      CMLCRP=CMLP*CRP
      CM1M=CM1M+CMLCRP*GM(ITM1PC,IT2PC)
      CM1P=CM1P+CMLCRP*GP(ITM1PC,IT2PC)
   45 IF(CLP.EQ.C0.OR.CMRP.EQ.C0) GO TO 50
      CLCMRP=CLP*CMRP
      CM2M=CM2M+CLCMRP*GM(ITM3PC,IT4PC)
      CM2P=CM2P+CLCMRP*GP(ITM3PC,IT4PC)
   50 GIM(IT1,I2)=C1M
      GIP(IT1,I2)=C1P
      GIM(IT3,I1  )=C2M
      GIP(IT3,I1  )=C2P
      GLM(IT1,I2)=CM1M*CCL
      GLP(IT1,I2)=CM1P*CCL
      GLM(IT3,I1  )=CM2M*CCR
      GLP(IT3,I1  )=CM2P*CCR
      [illegible]
      [illegible]
      [illegible] I-1,[illegible]
      NPI=[illegible]+1
      DO 67 J=1,NLM
      GIM(NPI,J)=C00
      GIP(NPI,J)=C00
      GLM(NPI,I)=C00
   67 GLP(NPI,J)=C00
      GIM(NPI,I)=(1.000,0.000)
   65 GIP(NPI,I)=(1.000,0.000)
   70 CONTINUE
      RETURN
      END

 SOURCE STATEMENTS = 145, PROGRAM SIZE = 12688 BYTES, PROGRAM NAME = GIGL

  NO DIAGNOSTICS GENERATED.

 COMPILATION 5 ******
```

```
EFFECT   NOLIST NOMAP NOXREF NOGOSTMT NODECK  SOURCE  TERM   OBJECT FIXED  NO
         OPT(3) LANGLVL(77) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

  *....*...1.........2.........3.........4.........5.........6.........7.*...

       SUBROUTINE GIGL
      1     (LMPC,NSPH)
       IMPLICIT REAL*8(A-H,O-Z)
       COMMON/DUM2/ RXX(4),RYY(4),RZZ(4),
      1RCS(4),CRI(4),XIL(4),
      2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
      3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IUG(4)
       COMMON/DUM3/GM(64,16),GP(64,16)
       COMMON/DUM4/GIM(64,16),GLM(64,16),GIP(64,16),GLP(64,16)
       COMMON/DUM6/FACTO(30),FNORM(28)
       COMPLEX*16 GM,GP,GIM,GLM,GIP,GLP,CCL,CCR,C1M,C2M,C1P,C2P,
      1CM1M,CM2M,CM1P,CM2P,CCO,XIL,XILI,RM,SM,W,AI,AF,AMMO,AEMO,S,
      2CRI,TSAS,SAC
       CO=0.D0
       CCO=(0.D0,0.D0)
       NLM=LMPC*LMPC
       N1=-NLM
       DO 70 NF=1,NSPH
       N1=N1+NLM
       XA=RXX(NF)
       RY=RYY(NF)
       RZ=RZZ(NF)
       IF(XA.EQ.CO.AND.RY.EQ.CO.AND.RZ.EQ.CO)GO TO 65
       DO 60 LF=1,LMPC
       L1=LF-1
       IL1=L1*L1+1
       ILM1=L1*(L1-1)+1
       MPM=LF+L1
       XNUM=M1 M
       XDEN=LF
       CCL=(0.D0,1.D0)*DSQRT(XNUM/XDEN)
       M1=-LF
       DO 50 MF=1,MPM
       M1=M1+1
       I1=IL1+M1
       II1=N1+I1
       II1MO=II1-1
       II1PO=II1+1
       II4MO=I1-1
       II4PO=I1+1
       IM1=ILM1+M1
       IIM1=N1+IM1
       IIM1MO=IIM1-1
       IIM1PO=IIM1+1
       C1M =DCLEB3(1,L1,L1   ,  1,M1-1)
       C1  =DCLEB3(1,L1,L1   ,  0,M1   )
       C1P =DCLEB3(1,L1,L1   ,-1,M1+1)
       C2M =DCLEB3(1,L1-1,L1,  1,M1-1)
       C2L =DCLEB3(1,L1-1,L1,  0,M1   )
       C2P =DCLEB3(1,L1-1,L1,-1,M1+1)
       DO 40 LS=LF,LMPC
       L2=LS-1
       IL2=L2*L2+1
       ILM2=L2*(L2-1)+1
       [illegible]
       [illegible]
       [illegible]
       CCI=L3+L2
       XNUM=L21
       XDEN=LS
       CCR=(0.D0,1.D0)*DSQRT(XNUM/XDEN)
       M2=-L-1
       DO 30 MS=1,MSM
       M2=M2+1
       I2=IL2+M2
       II2MO=I2-1
       II2PO=I2+1
       II3=N1+I2
       II3MO=II3-1
       II3PO=II3+1
       IM2=ILM2+M2
       IIM2MO=IM2-1
       IIM2PO=IM2+1
       IIM3=N1+IM2
       IIM3MO=IIM3-1
       IIM3PO=IIM3+1
       CM1 =DCLEB3(1,L2,L2   ,  1,M2-1)
       CM  =DCLEB3(1,L2,L2   ,  0,M2   )
```

```
 *....*...1.........2.........3.........4.........5.........6.........7.*....
      IT3MO=IT3-1
      IT3PO=IT3+1
      IM2=ILM2+M2
      ITM2=N2+IM2
      ITM2MO=ITM2-1
      ITM2PO=ITM2+1
      ITM3=N1+IM2
      ITM3MO=ITM3-1
      ITM3PO=ITM3+1
      CRM =DCLEB(1,L2,L2  , 1,M2-1)
      CR  =DCLEB(1,L2,L2  , 0,M2  )
      CRP =DCLEB(1,L2,L2  ,-1,M2+1)
      CMRM=DCLEB(1,L2-1,L2, 1,M2-1)
      CMR =DCLEB(1,L2-1,L2, 0,M2  )
      CMRP=DCLEB(1,L2-1,L2,-1,M2+1)
      CLCR=CL*CR
      C1 =     CLCR   *G(IT1   ,IT2   )
      C2 =     CLCR   *G(IT3   ,IT4   )
      C3 =     CLCR   *G(IT4   ,IT3   )
      C4 =     CLCR   *G(IT2   ,IT1   )
      CM1=CC0
      CM2=CC0
      CM3=CC0
      CM4=CC0
      IF(CML.EQ.C0) GO TO 15
      CMLCR=CML*CR
      CM1 =    CMLCR  *G(ITM1  ,IT2   )
      CM3 =    CMLCR  *G(ITM4  ,IT3   )
   15 IF(CLM.EQ.C0) GO TO 20
      CLCMR=CLM*CMR
      CM2 =    CLCMR  *G(ITM3  ,IT4   )
      CM4 =    CLCMR  *G(ITM2  ,IT1   )
   20 IF(CL.EQ.C0.OR.CRM.EQ.C0) GO TO 25
      CLCRM=CL*CRM
      C1 =C1+ CLCRM *G(IT1MO,IT2MO)
      C2 =C2+ CLCRM *G(IT3MO,IT4MO)
      C3 =C3+ CLCRM *G(IT4MO,IT3MO)
      C4 =C4+ CLCRM *G(IT2MO,IT1MO)
   25 IF(CML.EQ.C0.OR.CRM.EQ.C0) GO TO 30
      CMLCRM=CML*CRM
      CM1=CM1+CMLCRM*G(ITM1MO,IT2MO)
      CM3=CM3+CMLCRM*G(ITM4MO,IT3MO)
   30 IF(CLM.EQ.C0.OR.CMRM.EQ.C0) GO TO 35
      CLCMRM=CLM*CMRM
      CM2=CM2+CLCMRM*G(ITM3MO,IT4MO)
      CM4=CM4+CLCMRM*G(ITM2MO,IT1MO)
   35 IF(CLP.EQ.C0.OR.CRP.EQ.C0) GO TO 40
      CLCRP=CLP*CRP
      C1 =C1+ CLCRP *G(IT1PO,IT2PO)
      C2 =C2+ CLCRP *G(IT3PO,IT4PO)
      C3 =C3+ CLCRP *G(IT4PO,IT3PO)
      C4 =C4+ CLCRP *G(IT2PO,IT1PO)
   40 IF(CMLP.EQ.C0.OR.CRP.EQ.C0) GO TO 45
      CMLCRP=CMLP*CRP
      CM1=CM1+CMLCRP*G(ITM1PO,IT2PO)
      CM3=CM3+CMLCRP*G(ITM4PO,IT3PO)
   45 IF(CLMP.EQ.C0.OR.CMRP.EQ.C0) GO TO 50
      CLCMRP=CLMP*CMRP
      CM2=CM2+CLCMRP*G(ITM3PO,IT4PO)
      CM4=CM4+CLCMRP*G(ITM2PO,IT1PO)
   50 GH(IT1,IT2)=C1
      GH(IT3,IT4)=C2
      GH(IT4,IT3)=C3
      GH(IT2,IT1)=C4
      GK(IT1,IT2)=CM1*CCL
      GK(IT3,IT4)=CM2*CCR
      GK(IT4,IT3)=CM3*CCL
      GK(IT2,IT1)=CM4*CCR
   60 CONTINUE
      RETURN
      END

*   SOURCE STATEMENTS = 144, PROGRAM SIZE = 12714 BYTES, PROGRAM NAME = GHGK

*     NO DIAGNOSTICS GENERATED.

OF COMPILATION 4 ******
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```
     *....*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE GHGK
     1          (LMPC,NSPH)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUMC/ RXX(4),RYY(4),RZZ(4),
     1RCS(4),CRI(4),XIL(4),
     2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
     3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IOG(4)
      COMMON/DUM1/C(64,64)
      COMMON/DUM2/GH(64,64),GK(64,64)
      COMMON/DUM6/FACTO(30),FNORM(28)
      COMPLEX*16 G,GH,GK,CCL,CCR,C1,C2,C3,C4,CM1,CM2,CM3,CM4,CCO,XIL,
     1XILI,RM,SM,W,AI,AF,AMMO,AEMO,S,CRI,TSAS,SAC
      C0=0.0D0
      CC0=(0.0D0,0.0D0)
      NLM=LMPC*LMPC
      N=NSPH*NLM
      DO 10 NF=1,N
      DO 10 NS=1,N
      GH(NF,NS)=CC0
   10 GK(NF,NS)=CC0
      NSMO=NSPH-1
      N1=-NLM
      [illegible]=1,NSMO
      [illegible]+NLM
          ([illegible]-1)*NLM
      [illegible]+1
          [illegible]NSPH
      [illegible]+NLM
      [illegible] L1=0,LMPC
      L1=L[illegible]-1
      IL[illegible]=L[illegible]*L1+1
      IL[illegible]1=L1*(L1-1)+1
      [illegible]=L[illegible]+L1
      X[illegible]=[illegible]
      X[illegible]=L[illegible]
      CCL=(0.0D0,1.0D0)*DSQRT(XNUM/XDEN)
      M1=-[illegible]
      DO [illegible]=1,MFM
      M1=M1+1
      I1=IL1+M1
      II1=N1+I1
      II1MO=II1-1
      II1PO=II1+1
      II4=N2+I1
      II4MO=II4-1
      II4P =II4+1
      IM1=IL[illegible]1+M1
      [illegible]1+IM1
      [illegible]=II[illegible]1-1
      [illegible]=II[illegible]1+1
      [illegible]+IM1
      [illegible]-1
      [illegible]=II[illegible]+1
      [illegible]      ([illegible],L1          ,  1,M1-1)
      [illegible]      ([illegible],L1          ,  0,M1  )
      [illegible]      (1,L1,L1         , -1,M1+1)
      CM1=GHACC      (1,L1-1,L1,  1,M1-1)
      CM2=GHACC      (1,L1-1,L1,  0,M1  )
      CM3=GHACC      (1,L1-1,L1, -1,M1+1)
      [illegible] L3=L[illegible],LMPC
      L[illegible]=L3-1
      IL2=L3*L2+1
      IL[illegible]2=L2*(L2-1)+1
      ML=-L2
      IF(L[illegible].L1)ML=M1
      [illegible]=L3-ML
      L2T=L3+L2
      XNUM=L2T
      XDEN=L3
      CCR=(0.0D0,1.0D0)*DSQRT(XNUM/XDEN)
      M2=ML-1
      DO 60 MS=1,MSM
      M2=M2+1
      I2=IL2+M2
      II2=N2+I2
      II2MO=II2-1
      II2PO=II2+1
      II3=N1+I2
```

```
      *....*...1.........2.........3.........4.........5.........6.........7.*...
         20 CONTINUE
            GM(NI+I1,     I2)=PI4*SUM1*XILMNI
            GM(NI+I2,     I1)=PI4*SUM3*XILMN
            GP(NI+I1,     I2)=PI4*SUM2*XILMNI
            GP(NI+I2,     I1)=PI4*SUM4*XILMN
         30 CONTINUE
            GO TO 40
         32 DO 35 I=1,NLM
            NPI=NI+I
            DO 35 J=1,NLM
            GM(NPI,J)=CC0
         35 GP(NPI,J)=CC0
         40 CONTINUE
            RETURN
            END
CS*    SOURCE STATEMENTS = 88, PROGRAM SIZE = 9478 BYTES, PROGRAM NAME = GJMT     P
CS*     NO DIAGNOSTICS GENERATED.
  END OF COMPILATION 3 ******
```

```
                                  VS FORTRAN                    DATE 1984 NOV 07        TIME 17 37 23
 OPTIONS IN EFFECT  NOLIST NOMAP NOXREF NOGOSTMT NODECK   SOURCE   TERM    OBJECT FIXED  NO
                 OPT(0) LANGLVL(77) NOFIPS   FLAG(I)   NAME(MAIN  )   LINECOUNT(85)

     *....*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE GJMT
     1     (LMPO,NSPH,VK)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION YLM( 81),FJ(100)
      COMMON/DUM0/ RXX(4),RYY(4),RZZ(4),
     1RCS(4),CRI(4),XIL(4),
     2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
     3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IOG(4)
      COMMON/DUM3/GM(64,16),GP(64,16)
      COMMON/DUM6/FACT(30),FNORM(28)
      COMPLEX*16 YLM,XIL,XILI,GM,GP,XILMN,XILMNI,SUM1,SUM2,SUM3,SUM4,
     1XILTI,XILT,ACC1,ACC2,CCO,W,AI,AF,AMMO,AEMO,S,RM,SM,CRI,TSAS,SAC
      DATA PI4/ 12.566370614356/
      JCK=90
      C0=0.0D0
      CCO=(0.0D0,0.0D0)
      NLM=LMPO*LMPO
      LMTPO=LMPO+LMPO-1
      LMT=LMTPO-1
      N1= -NLM
      DO 40 NF=1,NSPH
      N1=N1+NLM
      RX=-RXX(NF)
      RY=-RYY(NF)
      RZ=-RZZ(NF)
      IF(RX.EQ.C0.AND.RY.EQ.C0.AND.RZ.EQ.C0) GO TO 32
      CALL POLAR(RX,RY,RZ,RR,CRTH,SRTH,CRPH,SRPH)
      CALL SPHAR(CRTH,SRTH,CRPH,SRPH,LMTPO,YLM)
      ARG=RR*VK
      CALL RBF(ARG,    LMT,JCK,FJ)
      DO 30 LF=1,LMPO
      L1=LF-1
      IL1=LF*L1+1
      MFM=LF+L1
      M1=-LF
      DO 30 MF=1,MFM
      M1=M1+1
      I1=IL1+M1
      DO 30 LS=LF,LMPO
      L2=LS-1
      IL2=LS*L2+1
      ML=-L2
      IF(L2.EQ.L1)ML=M1
      LMAXPO=LS+L1
      LMINPO=LS-L1
      XILMN=XIL(LMINPO)
      XILMNI=XILI(LMINPO)
      MSM=LS-ML
      L2T=LS+L2
      M2=ML-1
      DO 30 MS=1,MSM
      M2=M2+1
      I2=IL2+M2
      SUM1=CCO
      SUM2=CCO
      SUM3=CCO
      SUM4=CCO
      XILTI=-XILMNI
      XILT=-XILMN
      DO 20 LT=LMINPO,LMAXPO,2
      XILTI=-XILTI
      XILT=-XILT
      L3=LT-1
      M3=M1-M2
      CG=DCLEB(L2,L3,L1,M2,M3)
      IF(CG.EQ.C0) GO TO 20
      K=LT*L3+M3+1
      IF(CDABS(YLM(K)).LT.1.0D-8)GO TO 20
      MTM=LT+L3
      X=MTM
      RK=DSQRT(((L2T*X   )/(PI4*MFM)))*CG*DCLEB(L2,L3,L1,0,0)
      RJ=FJ(LT)*RK
      ACC1=RJ*DCONJG(YLM(K))
      ACC2=RJ*YLM(K)
      SUM1=SUM1+ACC1*XILTI
      SUM3=SUM3+ACC2*XILTI
      SUM2=SUM2+ACC1*XILT
      SUM4=SUM4+ACC2*XILT
```

```
      *....*...1.........2.........3.........4.........5.........6.........7.*...
            X=MIM
            X=DSQRT((L2I*X   )/(PI4*MFM))*CG*DCLEB(L2,L3,L1,0,0)
            FH=DCMPLX(FJ(LT),FN(LT))*X
            AUC1=FH*DCONJG(YLM(K))
            AUC2=FH*YLM(K)
            SUM1=SUM1+AUC1*XILTI
            SUM2=SUM2+AUC1*XILT
            SUM3=SUM3+AUC2*XILTI
            SUM4=SUM4+AUC2*XILT
         20 CONTINUE
            G(N1+I1,N2+I2)=PI4*SUM1*XILMNI
            G(N1+I2,N2+I1)=PI4*SUM3*XILMN
            G(N2+I1,N1+I2)=PI4*SUM2*XILMNI
            G(N2+I2,N1+I1)=PI4*SUM4*XILMN
         30 CONTINUE
            RETURN
            END
S*    SOURCE STATEMENTS = 89, PROGRAM SIZE = 9850 BYTES, PROGRAM NAME = GHMT     P
S*     NO DIAGNOSTICS GENERATED.
    COMPILATION 2 ******
```

```
N EFFECT    NOLIST NOMAP NOXREF NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED NO
             OPT(0) LANGLVL(77) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

      *....*...1.........2.........3.........4.........5.........6.........7.*...

            SUBROUTINE GHMT
           1      (LMPC,NSPH,VK)
            IMPLICIT REAL*8(A-H,O-Z)
            DIMENSION FJ(100),FN( 9),
           1YLM( 81)
            COMMON/DUMO/ RXX(4),RYY(4),RZZ(4),
           1ROS(4),CRI(4),XIL(4),
           2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
           3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IOG(4)
            COMMON/DUM1/G(64,64)
            COMMON/DUM6/FACTO(30),FNCRM(28)
            COMPLEX*16 G,XIL,XILI,YLM,XILMN,XILMNI,SUM1,SUM2,SUM3,SUM4,
           1XILT,XILTI,FH,AUC1,AUC2,CCO,RM,SM,W,AI,AF,AMMO,AEMO,S,CRI,TSAS,SAC
            DATA PI4/ 12.5663706143356/
            JCK=90
            CCO=(0.0D0,0.0D0)
            NLM=LMPC*LMPC
            N=NSPH*NLM
            LMTPC=LMPO+LMPC-1
            LMT=LMTPC-1
            DO 10 NF=1,N
            DO 10 NS=1,N
         10 G(NF,NS)=CCO
            NSMC=NSPH-1
            N1= -NLM
            DO 30 NF=1,NSMC
            N1=N1+NLM
            N2=(NF-1)*NLM
            NFPO=NF+1
            DO 30 NS=NFPO,NSPH
            N2=N2+NLM
            RX=RXX(NS)-RXX(NF)
            RY=RYY(NS)-RYY(NF)
            RZ=RZZ(NS)-RZZ(NF)
            CALL POLAR(RX,RY,RZ,RR,CRTH,SRTH,CRPH,SRPH)
            CALL SPHAR(CRTH,SRTH,CRPH,SRPH,LMTPO,YLM)
            ARG=RR*VK
            CALL RBF(ARG,    LMT,JCK,FJ)
            CALL RNF(ARG,    LMT,FN)
            DO 30 LF=1,LMPO
            L1=LF-1
            IL1=LF*L1+1
            MFM=LF+L1
            M1=-LF
            DO 30 MF=1,MFM
            M1=M1+1
            I1=IL1+M1
            DO 30 LS=LF,LMPO
            L2=LS-1
            IL2=LS*L2+1
            ML=-L2
            IF(L2.EQ.L1)ML=M1
            LMAXPO=LS+L1
            LMINPO=LS-L1
            XILMN=XIL(LMINPO)
            XILMNI=XILI(LMINPO)
            MSM=LS-ML
            L2T=LS+L2
            M2=ML-1
            DO 30 MS=1,MSM
            M2=M2+1
            I2=IL2+M2
            SUM1=CCO
            SUM2=CCO
            SUM3=CCO
            SUM4=CCO
            XILT=-XILMN
            XILTI=-XILMNI
            DO 20 LT=LMINPO,LMAXPO,2
            XILT=-XILT
            XILTI=-XILTI
            L3=LT-1
            M3=M1-M2
            CG=DCLEB(L2,L3,L1,M2,M3)
            IF(CG.EQ.0.0D0) GO TO 20
            K=LT*L3+M3+1
            IF(CDABS(YLM(K)).LT.1.0D-8)GO TO 20
            MTM=LT+L3
```

```
      WRITE(IW,6050)(S(I),I=IINR,IFNR)
      IF(IFNR.EQ.NLMM) GO TO 328
      IINR=IFNR+1
      IFNR=IFNR+4
      GO TO 325
  328 IF(JJ.EQ.1) GO TO 350
      JJ=1
      WRITE(IW,6060)
      IF(JIN.EQ.1) GO TO 335
      DO 330 I=1,NLMM
  330 S(I)=AEMO(I)
      GO TO 285
  335 DO 340 I=1,NLMM
      II=I+IN
  340 S(I)=AF(II+NM)
      GO TO 285
  350 IN=IN+NLMM
  355 WRITE(IW,6080)
      IF(JIN.EQ.NSPH) GO TO 370
  360 JIN=NSPH
      GO TO 260
  370 SCARAT=SCASEC/SCS
      IF(ICPI.NE.0) GO TO 380
      ABSRAT=1.000
      GO TO 385
  380 ABSRAT=ABSSEC/ACS
  385 TOTRAT=TOTSEC/TCS
      QSCA=SCASEC/GCS
      QABS=ABSSEC/GCS
      QTOT=TOTSEC/GCS
      IF(NHELP.EQ.1) TSAS(ISA,ISA)=TSAS(JSA,JSA)
      REFINR=DREAL(SAC(ISA,ISA))/DREAL(TSAS(ISA,ISA))
      ABSCOR=DIMAG(SAC(ISA,ISA))/DIMAG(TSAS(ISA,ISA))
      WRITE(IW,6100)SCASEC,ABSSEC,TOTSEC
      WRITE(IW,6300)SCARAT,ABSRAT,TOTRAT
      WRITE(IW,6400)QSCA,QABS,QTOT
      WRITE(IW,6700)ISA,ISA,SAC(ISA,ISA),JSA,ISA,SAC(JSA,ISA)
      WRITE(IW,6800)ISA,ISA,REFINR,ISA,ISA,ABSCOR
      IF(NHELP.NE.1) GO TO 100
      RBIRIF=(DREAL(SAC(JSA,JSA))-DREAL(SAC(ISA,ISA)))/DREAL(SAC(JSA,JSA
     1))
      RDICHR=(DIMAG(SAC(JSA,JSA))-DIMAG(SAC(ISA,ISA)))/DIMAG(SAC(JSA,JSA
     1))
      WRITE(IW,6900)JSA,ISA,RBIRIF,JSA,ISA,RDICHR
      GO TO 100
  400 READ(IR,5000)
      GO TO 400
  500 STOP
      END
*END PRINT          239 RECORDS
```

```
1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75..

      IF(IWCSS.EQ.1) WRITE(IW,6700)
     1ISA,ISA,TSAS(ISA,ISA),JSA,ISA,TSAS(JSA,ISA)
  142 CALL SZCT(LMPO,NSPH,IHELP,IEXP,VK,THK,PHK)
      IF(INVER.NE.0) GO TO 200
      IF(IWCIP.NE.1) GO TO 143
      WRITE(IW,6000)NAME
      WRITE(IW,6500)TCL,MAXIT,CI
  143 ITER=-1
      DO 145 K=1,NDIM
  145 AI(K)=BV(K)
      GO TO 170
  150 DO 160 K=1,NDIM
  160 AI(K)=AI(K)*CI+AF(K)*CF
  170 DO 190 I=1,NDIM
      DET=BV(I)
      DO 180 J=1,NDIM
      AMR=DREAL(AM(I,J))
      AMI=DIMAG(AM(I,J))
      AIR=DREAL(AI(J))
      AII=DIMAG(AI(J))
      IF(DABS(AMR).LT.1.D-36)AMR=0.0D0
      IF(DABS(AMI).LT.1.D-36)AMI=0.0D0
      IF(DABS(AIR).LT.1.D-36)AIR=0.0D0
      IF(DABS(AII).LT.1.D-36)AII=0.0D0
      AM(I,J)=DCMPLX(AMR,AMI)
      AI(J)=DCMPLX(AIR,AII)
  180 DET=DET-AM(I,J)*AI(J)
      DETR=DREAL(DET)
      DETI=DIMAG(DET)
      IF(DABS(DETR).LT.1.D-36)DETR=0.0D0
      IF(DABS(DETI).LT.1.D-36)DETI=0.0D0
      DET=DCMPLX(DETR,DETI)
  190 AF(I)=DET
      ITER=ITER+1
      IF(ITER.NE.0)OLSEC=SEC
      CALL [illegible](LMPO,NSPH,VK,IHELP,SCASEC,ABSSEC,TOTSEC)
      SEC=TOTSEC
      IF(ITER.EQ.0) GO TO 150
      DELTA=OLSEC/SEC-1.0D0
      IF(IWCIP.EQ.1)WRITE(IW,6600)ITER,OLSEC,SEC,DELTA
      IF(DABS(DELTA).LT.TCL)GO TO 250
      IF(ITER.LT.MAXIT)GO TO 150
      [illegible]
  200 IF([illegible].EQ.4) CALL SMAT(LMPO,NSPH)
      DO 205 I=1,NDIM
  205 AM(I,I)=AM(I,I)+1.0D0
      CALL [illegible](AM,V,NDDMST,NDIM,MODE,IER )                       F413
      IF(IER.NE.1) GO TO 400
      DO [illegible] I=1,NDIM
      [illegible]
      DO [illegible] J=1,NDIM
      DET=DET+AM(I,J)*BV(J)
  210 AF(I)=DET
      CALL [illegible](LMPO,NSPH,VK,IHELP,SCASEC,ABSSEC,TOTSEC)
      WRITE(IW,[illegible])NAME
      [illegible]=
      IF(IWMA)[illegible],[illegible],250
  250 JIN=1
  260 DO 355 J=JIN,NSPH
      JJ=
      IF(JIN.[illegible].1) GO TO 275
      DO 270 I=1,NLMM
  270 S(I)=[illegible](I)
      GO TO 285
  275 DO 280 I=1,NLMM
      II=I+[illegible]
  280 S(I)=AF(II)
  285 WRITE(IW,[illegible])
      IF(JJ.[illegible].0)) [illegible] 295
      WRITE(IW,6[illegible])
      [illegible]
  [illegible] WRITE(IW,[illegible])
      WRITE(IW,[illegible])
      IF(J[illegible].1) GO TO 31[illegible]
      WRITE(IW,[illegible])
      GO TO 320
   31 WRITE(IW,[illegible])
  320 IIN=1
      IIN=4
  325 IF(IFN[illegible].GT.NLMM)IFNR=NLMM
```

```
1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75..

      READ(IR,5040)NAME
      THK=THK*PIG/180.
      PHK=PHK*PIG/180.
      NHELP=0
  108 IF(IHELP)112,115,110
  110 JHELP=1
      ISA=1
      JSA=2
      GO TO 113
  112 JHELP=-1
      ISA=2
      JSA=1
  113 IHELP=JHELP
      GO TO 117
  115 IHELP=-JHELP
      NHELP=1
      GO TO 108
  117 IF(JGO.NE.1) GO TO 120
      LM=LMPO-1
      NLM=LMPO*LMPO
      NLMM=NLM-1
      N=NSPH*NLM
      [illegible]=N-NSPH
      [illegible]=[illegible]+4
      [illegible]=1.[illegible]
      CALL [illegible]ATE(LMPO)
  [illegible] IF(JGO.[illegible].2.OR.JGO.EQ.3.OR.NHELP.EQ.1) GO TO 125
      [illegible] NHELP=1,[illegible]
  [illegible] CALL [illegible](NHELP,THK,PHK,LMPO)
  125 IF(JG[illegible].OR.JGO.EQ.4) GO TO 130
      CALL SRMT(LMPO,NSPH,VK)
      CALL SUMT(LMPO,NSPH,VK)
      CALL SRGN(LMPO,NSPH)
      CALL SISL(LMPO,NSPH)
  130 IF(JGO.[illegible].4) GO TO 142
      CALL [illegible](LMPO,NSPH,VK)
      CALL [illegible](LMPO,NSPH)
      CONST=[illegible]/(VK*VK)
      CC[illegible]=-(0.000,1.000)*(.5*CONST/VK)
      SCS=0.000
      TCS=0.000
      ACS=0.000
      [illegible]=0.000
      TSAS(ISA,ISA)=(0.000,0.000)
      TSAS(JSA,ISA)=(0.000,0.000)
      ICRI=0
      DO 140 NS=1,NSPH
      IF(CDABS(CRI(NS)).NE.0.000)ICRI=ICRI+1
      GCSS=PI5*RDS(NS)*RDS(NS)
      [illegible]=GCSS+GCSS
      [illegible]
      DET=(0.000,0.000)
      CFDET=(0.000,0.000)
      SCASEC=0.000
      DO 137 [illegible]=1,L[illegible]
      [illegible]+1
      DO 137 [illegible]=1,L[illegible]
      K=K+1
      A=W(K,ISA)*[illegible](L,NS)
      B=W(K,JSA)*[illegible](L,NS)
      SCASEC=SCASEC+CDABS(A)**2+CDABS(B)**2
      CFDET=CFDET+DCONJG(W(K,JSA))*(A-B)
  137 DET=DET+DCONJG(W(K,ISA))*(A+B)
      SCASEC=SCASEC*CONST
      TOTSEC=-DREAL(DET)*CONST
      ABSSEC=TOTSEC-SCASEC
      SCS=SCS+SCASEC
      TCS=TCS+TOTSEC
      ACS=ACS+ABSSEC
      QSCA=SCASEC/GCSS
      QTOT=TOTSEC/GCSS
      QABS=ABSSEC/GCSS
      TSAS(ISA,ISA)=TSAS(ISA,ISA)+DET*CCON
      TSAS(JSA,ISA)=TSAS(ISA,JSA)+CFDET*CCON
      IF(IWCSS.NE.1) GO TO 140
      WRITE(IW,6[illegible]0)NAME
      WRITE(IW,6200)NS
      WRITE(IW,6100)SCASEC,ABSSEC,TOTSEC
      WRITE(IW,6400)QSCA,QABS,QTOT
  140 CONTINUE
```

```
      IMPLICIT REAL*8(A-H,O-Z)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CCC                                                                   CCC
CCC                            PRG 1                                  CCC
CCC                                                                   CCC
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      COMMON/DUM0/ RXX(4),RYY(4),RZZ(4),
     1ROS(4),CRI(4),XIL(4),
     2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
     3A(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IOG(4)
      COMMON/DUM1/G(64,64)
      COMMON/DUM2/GH(64,64),GK(64,64)
      COMMON/DUM3/GM(64,16),GP(64,16)
      COMMON/DUM4/GIM(64,16),GLM(64,16),GIP(64,16),GLP(64,16)
      COMMON/DUM5/AM(120,120),BV(120),V(120)
      COMMON/DUM6/FACTO(30),FNORM(20)
      COMPLEX*16 CRI,XIL,XILI,RM,SM,G,GM,GP,GH,GK,GIM,GLM,GIP,GLP,
     1AM,BV,V,DLT,AI,AF,AMMO,AEMO,S,SSMSP,SSESP,A,B,UFDET,CCUN,TSAS,SAC
      DATA PIG/3.14159265359/
 5000 FORMAT(4I12)
 5010 FORMAT(3D20.8)
 5015 FORMAT(F20.8,2F10.4)
 [illegible] FORMAT(1[illegible])
 [illegible] FORMAT(2[illegible].[illegible])
 [illegible] [illegible](20A4)
 [illegible] FORMAT(1H ,////,1H ,[illegible],[illegible],/,1H ,[illegible]X,20A4,///)
 [illegible] FORMAT(1H1,1[illegible]X,'CALCULATIONS BELOW REFER TO DATASET ',3A4,//)
 [illegible] FORMAT(1H ,[illegible]X,14HAMPLITUDES OF  )
 [illegible] FORMAT(1H+,[illegible]X,8HMAGNETIC)
 [illegible] FORMAT(1H+,[illegible],1[illegible] MULTIPOLES AROUND )
 [illegible] FORMAT(1H+,[illegible]X,7HCENTER ,I2,/)
 [illegible] FORMAT(1H ,4(5X,D15.7))
 [illegible] FORMAT(1H ,/)
 [illegible] FORMAT(1H+,54X,8HELECTRIC)
 [illegible] FORMAT(1H ,//)
 [illegible] [illegible](1H+, 1X,[illegible],/)
 [illegible] FORMAT(1H ,[illegible]X,7HSCASEC=,D15.7,8X,7HABSSEC=,D15.7,8X,7HTOTSEC=,
     1D15.7,//)
 [illegible] FORMAT(1H ,2[illegible]X,'CROSS SECTIONS OF SPHERE ',I2,/)
 [illegible] FORMAT(1H ,[illegible]X,7HSCARAT=,D15.7,8X,7HABSRAT=,D15.7,8X,7HTOTRAT=,
     1D15.7,//)
 [illegible] FORMAT(1H ,[illegible]X,7H QSCAS=,D15.7,8X,7H QABSS=,D15.7,8X,7H QTOTS=,
     1D15.7,//)
 [illegible] FORMAT(1H ,1[illegible]X,'ITE[illegible]            DESEC                NWSEC
     1[illegible]                 ( TOL=',D10.3,', MAXIT=',I2,', CI=',D10.3,1H),//)
 [illegible] FORMAT(1H ,15X,I[illegible],3D20.8)
 [illegible] FORMAT(1H ,1[illegible]X,2(10X,2I1,3X,2D20.8))
 [illegible] FORMAT(1H ,1[illegible]X,2(10X,2I1,3X,[illegible].8))
      I[illegible]=
      I[illegible]
      [illegible] IDATA,JDATA,KDATA
      [illegible](I[illegible],[illegible])
      [illegible] IDATA,JDATA,KDATA
      [illegible] IJOC,IWMA,IWCSS,IWCIP

C     [illegible] [illegible] SET JOC=1.
CCC   [illegible] SET JOC=2.
CCC   [illegible] SET JOC=3.
CCC   [illegible] THK OR PHK SET JOC=4.
CCC   [illegible] JOC =1[illegible].
CCC
CCC   IF [illegible] MULTIPOLAR EXPANSION COEFFICIENT IS WRITTEN
CCC
CCC   IF IWMA [illegible] MULTIPOLAR EXPANSION COEFFICIENTS
CCC   [illegible] ARE ALSO WRITTEN.
CCC
CCC   IF IWCSS=1 CROSS SECTIONS OF THE SINGLE SPHERES ARE WRITTEN.
CCC
CCC   IF IWCIP=1 DATA ABOUT CONVERGENCE OF ITERATIVE
CCC   PROCEDURE ARE WRITTEN.
CCC
      IF(JOC.GT.4) [illegible]
      READ(I[illegible],5000) NSPH,LMPO,IHELP,IEXP,MAXIT
      READ(I[illegible],5010)(RXX(I),RYY(I),RZZ(I),I=1,NSPH)
      READ(I[illegible],[illegible])(I[illegible](I),I=1,NSPH)
      READ(I[illegible],[illegible]010)(ROS(I),I=1,NSPH)
      READ(I[illegible],[illegible])(CRI(I),I=1,NSPH)
      READ(I[illegible],5015)VK,THK,PHK
      READ(I[illegible],[illegible])INVER, MODE,NORMST
      READ(IR,[illegible])CI,TOL
```

```
                           VS FORTRAN
 OPTIONS IN EFFECT:  NOLIST NOMAP NOXREF NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOT
                     OPT(0) LANGLVL(77) NOFIPS    FLAG(I)   NAME(MAIN   )  LINECOUNT(65)

      *....*...1.........2.........3.........4.........5.........6.........7.*...
            SUBROUTINE SZOT
         1        (LMPC,NSPH,IHELP,IEXP,VK,THK,PHK)
            IMPLICIT REAL*8(A-H,O-Z)
            COMMON/DUMO/ RXX(4),RYY(4),RZZ(4),
           1RCS(4),CRI(4),XIL(4),
           2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
           3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),ICG(4)
            COMMON/DUM4/GIM(64,16),GLM(64,16),GIP(64,16),GLP(64,16)
            COMMON/DUM5/AM(120,120),BV(120),V(120)
            COMPLEX*16 W,GIM,GLM,BV,SUM,CRI,XIL,XILI,RM,SM,AI,AF,AMMO,
           1AEMO,S,GIP,GLP,AM,SSMSP,SSESP,PHAS,TSAS,SAC
            NLMM=LMPC*LMPC-1
            NM=NSPH*NLMM
            IF(IHELP.EQ.1) GO TO 2
            ISA=2
            JSA=1
            GO TO  3
          2 ISA=1
            JSA=2
          3 IF(IEXP.NE.0)GO TO 30
            IK=1
            L=1
            IL=3
            DO 20 I=1,NM
            SSMSP=RM(L,IK)
            SSESP=SM(L,IK)
            IF(I.LT.IL)GO TO 5
            L=L+1
            IF(L.GT.LMPC)L=1
            IL=IL+L+L+1
          5 II=I+IK
            IN=I/NLMM+1
            SUM=(0.D00,0.D00)
            DO 10 J=1,NLMM
            JPC=J+1
         10 SUM=SUM+W(J,ISA)*(GLM(II,JPC)*IHELP+GIM(II,JPC))
            SUR=DREAL(SUM)
            SUI=DIMAG(SUM)
            IF(DABS(SUR).LT.1.D-20)SUR=0.D00
            IF(DABS(SUI).LT.1.D-20)SUI=0.D00
            SUM=DCMPLX(SUR,SUI)
             V(I)=-SUM*SSMSP
         20  V(I+NM)=-SUM*SSESP*IHELP
            RETURN
         30 CKX=VK*DSIN(THK)*DCOS(PHK)
            CKY=VK*DSIN(THK)*DSIN(PHK)
            CKZ=VK*DCOS(THK)
            DO 40 I=1,NSPH
            IJ=(I-1)*NLMM
            PHDF=CKX*RXX(I)+CKY*RYY(I)+CKZ*RZZ(I)
            PHAS=CDEXP((0.0,1.0)*PHDF)
            K=1
            NIPC=K+K+1
            SSMSP=RM(K,I)
            SSESP=SM(K,I)
            DO 40 J=1,NLMM
            II=IJ+J
             V(II)=-W(J,ISA)*PHAS*SSMSP
             V(II+NM)=-W(J,ISA)*PHAS*SSESP*IHELP
            IF(J.LT.NIPC)GO TO 40
            K=K+1
            NIPC=NIPC+K+K+1
            SSMSP=RM(K,I)
            SSESP=SM(K,I)
         40 CONTINUE
            RETURN
            END
 *STATISTICS*  SOURCE STATEMENTS = 62, PROGRAM SIZE = 5786 BYTES, PROGRAM NAME = SZOT     P
 *STATISTICS*  NO DIAGNOSTICS GENERATED.
 ****** END OF COMPILATION 6 ******
```

```
                                     VS FORTRAN              DATE  1984 NOV 07       TIME  17 40 00

  OPTIONS IN EFFECT:  NOLIST NOMAP NOXREF NOGOSTMT NODECK   SOURCE    TERM    OBJECT FIXED  NOT
                       OPT(0) LANGLVL(77) NOFIPS    FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

          *....*...1.........2.........3.........4.........5.........6.........7.*....

                SUBROUTINE WLM
               1(KHELP,TH,PH,LMPC)
                IMPLICIT REAL*8(A-H,O-Z)
                DIMENSION YLM(81)
                COMMON/DJ40/ RXX(4),RYY(4),RZZ(4),
               1ROS(4),CRI(4),XIL(4),
               2AILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
               3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IOG(4)
                COMMON/DUM6/FACTC(30),FNORM(28)
                COMPLEX*16 YLM,XIL,W,AP,AM,AZ,CL,XILI,CRI,AI,AF,AMMO,AEMO,S,
               1RM,SM,TSAS,SAC
                DATA PI4/ 12.566370614356/
                NLMP=LMPC*LMPC+1
                YLM(NLMP)=(0.0D0,0.0D0)
                IHELP=1
                IF(KHELP.EQ.2) IHELP=-1
                P=-IHELP
                COST=DCOS(TH)
                SINT=DSIN(TH)
                COSP=DCOS(PH)
                SINP=DSIN(PH)
                CALL SPHAR(COST,SINT,COSP,SINP,LMPC,YLM)
                ALPH1=-COST*COSP
                BETA1=-COST*SINP
                GAM1=SINT
                ALPH2=-SINP
                BETA2=-COSP
                GAM2=0.D0
                AP=.5*(DCMPLX(ALPH1,P*ALPH2)+DCMPLX(BETA1,P*BETA2)*(0.0D0,1.0D0))
                AM=.5*(DCMPLX(ALPH1,P*ALPH2)-DCMPLX(BETA1,P*BETA2)*(0.0D0,1.0D0))
                AZ=DCMPLX(GAM1,P*GAM2)
                DO 20 LF=2,LMPC
                L=LF-1
                LFTL=LF*L
                X=LFTL
                CL=PI4*XIL(LF)/DSQRT(X)
                MV=L+LF
                M=-LF
                DO 20 MF=1,MV
                M=M+1
                K=LFTL+M
                X=LFTL-M*(M+1)
                CP=DSQRT(X)
                X=LFTL-M*(M-1)
                CM=DSQRT(X)
                CZ=M
             20 W(K,KHELP)=DCONJG(AM*CP*YLM(K+2)+AP*CM*YLM(K)+AZ*CZ*YLM(K+1))*CL
                RETURN
                END

   *STATISTICS*  SOURCE STATEMENTS =   44, PROGRAM SIZE =  6044 BYTES, PROGRAM NAME = WLM     PA
   *STATISTICS*  NO DIAGNOSTICS GENERATED.
   ****** END OF COMPILATION ******
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[illegible]                    VS FORTRAN                  DATE  1984 NOV 07        TIME  17 40 [illegible]

[illegible] EFFECT     NOLIST  NOMAP NOXREF  NOGOSTMT NODECK    SOURCE    TERM    OBJECT FIXED   NOT
                  OPT(0) LANGLVL(77) NOFIPS    FLAG(I)   NAME(MAIN  )  LINECOUNT(85)

       *....*...1.........2.........3.........4.........5.........6.........7.*....

             SUBROUTINE RSM
            1      (LMPC,NGRMX,VK)
             IMPLICIT REAL*8(A-H,O-Z)
             COMMON/DUMO/ RXX(4),RYY(4),RZZ(4),
            1RUS(4),CRI(4),XIL(4),
            2XILI(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
            3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IOG(4)
             DIMENSION
            1CFJ(100),FN(6),FJ(100)
             COMPLEX*16 RM,SM,CRI,CFJ,CRII,VKN,DCFJ,A,B,C,D,XIL,XILI
            1,W,AI,AF,AMMO,AEMO,S,TSAS,SAC
             JCL=95
             LM=LMPC-1
             LMPT=LMPC+1
             DO 20 I=1,NGRMX
             IOGI=IOG(I)+1
             IF(IOGI.GT.I) GO TO 6
             IOGI=IOGI-1
             DO 5 L=1,LM
             [illegible](L,I)=RM(L,IOGI)
           5 [illegible](L,I)=SM(L,IOGI)
             GO TO 20
           6 VKN=VK*R[illegible](I)
             [illegible]I(I)
             [illegible]
             [illegible]
             IF(DIMAG(VKN).[illegible]0.0D0) GO TO 7
             CALL [illegible](VKN,LMPC,JCL,CFJ)
             [illegible]
           7 [illegible]=D[illegible](VKN)
             CALL RS[illegible](VKN,LMPC,JCL,FJ)
             DO 8 J=1,LMPT
           8 CFJ(J)=FJ(J)
           9 CALL [illegible](VKR,LMPC,JCL,FJ)
             CALL RN[illegible](VKR,LMPC,FN)
             [illegible] LD=2,LMPC
             L=LD-1
             E=LD+L
             L[illegible]=LD+1
             DFN=(L*FN(L)-LD*FN(LDPC))
             DFJ=(L*FJ(L)-LD*FJ(LDPC))
             DCFJ=(L*CFJ(L)-LD*CFJ(LDPC))
             A=CFJ(LD)*(VKR*DFN+FN(LD)*E)
             B=VKN*DCFJ+CFJ(LD)*E
             C=CFJ(LD)*(VKR*DFJ+FJ(LD)*E)
             D=FJ(LD)*B
             [illegible]=FN(LD)*B
             [illegible](L,I)=1.0D0/(1.0D0+(0.0D0,1.0D0)*((A-B)/(C-D)))
             [illegible](L,I)=1.0D0/(1.0D0+(0.0D0,1.0D0)*((CRII*A-B)/(CRII*C-D)))
          20 CONTINUE
             RETURN
             [illegible]

       [illegible] 40, PROGRAM SIZE = 7730 BYTES, PROGRAM NAME = RSM     PAG

       [illegible]

       [illegible] ******
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```
[illegible] SOURCE TERM OBJECT FIXED NOT
OPT(0) LANGLVL(77) NOFIPS FLAG(I) NAME(MAIN ) LINECOUNT(85)

*....*...1.........2.........3.........4.........5.........6.........7.*....

      SUBROUTINE AUXIL
     1(LMPO)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUM0/ RXX(4),RYY(4),RZZ(4),
     1RES(4),CRI(4),XIL(4),
     2XIL1(4),RM(3,4),SM(3,4),TSAS(2,2),SAC(2,2),
     3W(15,2),AI(120),AF(120),AMMO(15),AEMO(15),S(15),NAME(40),IOG(4)
      COMMON/DUM6/FACTO(30),FNORM(28)
      COMPLEX*16 XIL,XIL1,CRI,RM,SM,W,AI,AF,AMMO,AEMO,S,TSAS,SAC
      DATA PI4/ 12.566370614356/
      NFAC=30
      FACTO (1)=1.0D0
      DO 1 I=2,NFAC
      A=I-1
    1 FACTO (I)=A*FACTO (I-1)
      LMTPO=LMPO+LMPO-1
      DO 5 LF=1,LMTPO
      L=LF-1
      LTPO=LF+L
      DO 5 IM=1,LF
      M=IM-1
      LMM=LF-M
      LPM=LF+M
      [illegible]
      [illegible]*FACTO(LMM)/FACTO(LPM)
      A=[illegible]/PI4
      F[illegible] (K)=DSQRT(A)
      I=[illegible]
      I=I+1
      XIL1(I)=1
      XIL (I)=1
      IF(I.EQ.LMPO) GO TO 15
      I=I+1
      XIL1(I)=(0.0D0,-1.0D0)
      XIL (I)=(0.0D0, 1.0D0)
      IF(I.EQ.LMPO) GO TO 15
      I=I+1
      XIL1(I)=-1
      XIL (I)=-1
      IF(I.EQ.LMPO) GO TO 15
      I=I+1
      XIL1(I)=(0.0D0, 1.0D0)
      XIL (I)=(0.0D0,-1.0D0)
      IF(I.LT.LMPO) GO TO 12
   15 RETURN
      END

[illegible] STATEMENTS = 42, PROGRAM SIZE = 2888 BYTES, PROGRAM NAME = AUXIL

[illegible] DIAGNOSTICS GENERATED.

[illegible] 11 ******
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[illegible]                                               SOURCE   TERM   OBJECT FIXED  NO[illegible]
              OPT(0) LANGLVL(77) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

     *....*...1.........2.........3.........4.........5.........6.........7.*...

            FUNCTION DCLEB(JA,JB,JC,MA,MB)
            IMPLICIT REAL*8(A-H,O-Z)
            COMMON/DUMB/FACTO(30),FNORM(28)
            MC=MA+MB
            IF(MA-JA)4,4,3
       3    DCLEB=0.D0
            GOTO35
       4    IF(MA+JA)5,6,6
       5    DCLEB=0.D0
            GOTO35
       6    IF(MB-JB)8,8,7
       7    DCLEB=0.D0
            GOTO35
       8    IF(MB+JB)9,10,10
       9    DCLEB=0.D0
            GOTO35
      10    IF(MC-JC)12,12,11
      11    DCLEB=0.D0
            GOTO35
      12    IF(MC+JC)13,14,14
      13    DCLEB=0.D0
            GOTO35
      14    IF(JC-JA-JB)16,16,15
      [illegible]
            GOTO35
      16    JJ1=JA+JB-JC+1
            JJ2=JC+JA-JB+1
            JJ3=JC-JA+JB+1
            JJ4=JA+JB+JC+2
            JJ5=JA+MA+1
            JJ6=JA-MA+1
            JJ7=JB+MB+1
            JJ8=JB-MB+1
            JJ9=JC+MC+1
            JJ10=JC-MC+1
            JJ17=-JC+JB-MA
            JJ18=-JC+JA+MB
            JJ19=JA+JB-JC
            JJ20=JA-MA
            JJ21=JB+MB
            IF(JJ17)17,17,20
      17    IF(JJ18)18,18,19
      18    K=0
            GOTO24
      19    K=JJ18
            GOTO24
      20    IF(JJ18)21,21,22
      21    K=JJ17
            GOTO24
      22    IF(JJ17-JJ18)19,19,21
      24    IF(JJ21-JJ19)25,25,26
      25    IF(JJ19-JJ20)23,23,27
      [illegible]
      [illegible]
      [illegible]
      [illegible]
            IF(JJ[illegible]-JJ[illegible])[illegible]
            [illegible]
            [illegible]=0.
            I=
            IF(K-2*(K/2))31,30,31
      30    BOY=1.D0
            GOTO32
      31    BOY=-1.D0
      32    JJ11=I+1
            JJ12=JJ1-I
            JJ13=JJ6-I
            JJ14=JJ7-I
            JJ15=JC-JB+MA+I+1
            JJ16=JC-JA-MB+I+1
            PRODD =FACTO (JJ11)*FACTO (JJ12)*FACTO (JJ13)
           1*FACTO (JJ14)*FACTO (JJ15)*FACTO (JJ16)
            SUM=SUM+BOY/PRODD
            IF(I-KK)33,34,34
      33    I=I+1
            BOY=-BOY
            GOTO32
      34    [illegible]=2*JC+1
```

```
        *....*....1....*....2....*....3....*....4....*....5....*....6....*....7.*....
 78             SQUA 1=ARG*FACTO (JJ1)*FACTO (JJ2)*FACTO (JJ3)
 79             SQUA 2=FACTO (JJ4)
 80             SQUA 3=FACTO (JJ5)*FACTO (JJ6)*FACTO (JJ7)
               1*FACTO (JJ8)*FACTO (JJ9)*FACTO (JJ10)
 81             SQUA 4=SQUA 1*SQUA 3/SQUA 2
 82             DCLEB=SUM*DSQRT(SQUA 4)
 83        55   RETURN
 84             END

IOS*    SOURCE STATEMENTS = 84, PROGRAM SIZE = 4774 BYTES, PROGRAM NAME = DCLEB

IOS*     NO DIAGNOSTICS GENERATED.

END OF COMPILATION 12 ******
```

```
[illegible]
  [illegible]  NOLIST NOMAP NOXREF NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOT
           OPT( ) LANGLVL(77) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

     *....*...1.........2.........3.........4.........5.........6.........7.*....

            SUBROUTINE RBF(X,N,JCK,FJ)
            IMPLICIT REAL*8(A-H,O-Z)
            DIMENSION FJ(100)
            ICK=JCK
            IF(X-1.E-8)7,11,11
          7 FJ(1)=1.
            IF(N)10,10,8
          8 MM=N+1
            DO 9 M=2,MM
          9 FJ(M)=0.
         10 GO TO 50
         11 FNO=1.34*X+6.5
            TST=4.21*.4342944819*DLOG(X)+3.
            IF(2.-TST)13,12,12
         12 DELTA=2.
            GO TO 14
         13 DELTA=TST
         14 FN=N
            IF(FN-FNO)15,15,16
         15 FMS=FNO+DELTA
            GO TO 17
         16 FMS=FN+DELTA
         17 M=FMS+1.
[illegible]
            FJ(M)=((FM+FM+3.)/X)*FJ(M+1)-FJ(M+2)
            IF(DABS(FJ(M))-1.E+50)23,33,33
         23 IF(M-1)25,25,24
         24 M=M-1
            FM=FM-1.
[illegible]
            IF(X-.2)26,27,27
         26 XX=X*X
            XXXX=XX*XX
            X6=XXXX*XX
            SER=1.-XX/6.+XXXX/120.-X6/5040.
            CON=FJ(1)/SER
            JJ=1
            GO TO 31
         27 SER=DSIN(X)
            IF(DABS(SER)-.1)28,29,29
         28 IF(X-.11)[illegible],29,30
         29 CON=X*FJ(1)/SER
            JJ=1
[illegible]
                      ...*FJ(...)/(...*X/(...DCOS(X))
[illegible]

  NUMBER OF STATEMENTS = 44, PROGRAM SIZE = 3614 BYTES, PROGRAM NAME = RBF     PA
  NO DIAGNOSTICS GENERATED.
  END OF COMPILATION 13 ******
```

```
                          VS FORTRAN                 DATE  1984 NOV                TIME
OPTIONS IN EFFECT*  NOLIST NOMAP NOXREF NOGOSTMT NODECK    SOURCE     TERM    OBJECT FIXED  NOT
                    OPT(0) LANGLVL(77) NOFIPS    FLAG(I)   NAME(MAIN  )   LINECOUNT(85)

         *....*...1.........2.........3.........4.........5.........6.........7.*....

               SUBROUTINE RNF(X,L,FN)
               IMPLICIT REAL*8(A-H,O-Z)
               DIMENSION FN(1)
               IF(X.LT.0.0D0.OR.L.LT.0) RETURN
               LP0=L+1
               IF(X.GT.0.0D0) GO TO 20
               DO 10 I=1,LP0
            10 FN(I)=-1.0D50
            20 FN1=-DCOS(X)/X
               FN2=(FN1-DSIN(X))/X
               FN(1)=FN1
               FN(2)=FN2
               IF(L.LT.2) RETURN
               XI=1.0D0/X
               LM0=L-1
               DO 30 I=1,LM0
               ITP0=I+I+1
               IPT=I+2
               FN0=FN1
               FN1=FN2
               FN2=FN1*XI*ITP0-FN0
            30 FN(IPT)=FN2
               RETURN
               END

 *STATISTICS*  SOURCE STATEMENTS = 24, PROGRAM SIZE = 1664 BYTES, PROGRAM NAME = RNF      PAG
 *STATISTICS*  NO DIAGNOSTICS GENERATED.
 END OF COMPILATION 14 ******
```

```
[illegible]              VS FORTRAN              DATE [illegible]        TIME [illegible]

[illegible]   NOLIST NOMAP NOXREF NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOT
      OPT(0) LANGLVL(77) NOFIPS   FLAG(I)   NAME(MAIN  )  LINECOUNT(85)

    *....*...1.........2.........3.........4.........5.........6.........7.*....

            SUBROUTINE CBF(X,N,JCK,FJ)
            IMPLICIT REAL*8(A-H,O-Z)
            DIMENSION FJ(100)
            COMPLEX*16 FJ,X,XX,XXXX,X6,SER,CCN,CCN1
            Y=CDABS(X)
            ICK=JCK
            IF(Y-1.E-3) 7,11,11
          7 FJ(1)=1.
            IF(N)10,10,8
          8 MM=N+1
            DO 9 M=2,MM
          9 FJ(M)=0.
         10 RETURN
         11 FNC=1.34*Y+6.5
            TST=+.21*DLOG10(Y)+3.
            IF(2.-TST)13,12,12
         12 DELTA=2.
            GO TO 14
         13 DELTA=TST
         14 FN=N
            IF(FN-FNC)15,15,16
         15 FNS=FNC+DELTA
            GO TO 17
         16 FNS=FN+DELTA
         17 NS=FNS+1.
            ICK=NS+2
            IF(ICK-JCK)21,21,16
         [illegible] GO TO [illegible]
         21 FJ(NS+1)=0.
            FJ(NS)=(1.D-37,1.D-37)
            M=NS-1
            FM=M-1
         22 FJ(M)=((FM+FM+3.)/X)*FJ(M+1)-FJ(M+2)
            IF(CDABS(FJ(M))-1.D33)23,33,33
         23 IF(M-1)25,25,24
         24 M=M-1
            FM=FM-1.
            GO TO 22
         25 IF(Y-.[illegible])26,27,27
            XX=X*X
            XXXX=XX*XX
            X6=XXXX*XX
            SER=1.-XX/6.+XXXX/120.-X6/5040.
            CCN=FJ(1)/SER
            JJ=1
            GO TO 31
         27 SER=CDSIN(X)
            IF(CDABS(SER)-.1)28,29,29
         28 IF(Y-.11)29,29,30
         29 CCN=X*FJ(1)/SER
            JJ=1
            GO TO 31
         30 CCN1=X*FJ(1)/SER
            FJ(1)=FJ(1)/CCN1
            CCN=X*FJ(2)/(SER/X-CDCOS(X))
            JJ=2
         31 MM=N+1
            DO 32 M=JJ,MM
         32 FJ(M)=FJ(M)/CCN
            RETURN
         33 JJ=M+1
            DO 34 J=JJ,NS
         34 FJ(J)=FJ(J)*1.E-33
            GO TO 22
            END

   *STATISTICS*  SOURCE STATEMENTS = [illegible], PROGRAM SIZE = 5118 BYTES, PROGRAM NAME = CBF     PAC

   *STATISTICS*  NO DIAGNOSTICS GENERATED.

   [illegible] END OF COMPILATION [illegible] ******
```

```
[illegible]
[illegible]   SOURCE   TERM   OBJECT FIXED  NOT
    OPT( ) LANGLVL(77) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

*....*...1.........2.........3.........4.........5.........6.........7.*....

      SUBROUTINE POLAR(X,Y,Z,R,CTH,STH,CPH,SPH)
      IMPLICIT REAL*8(A-H,O-Z)
      RHO=X*X+Y*Y
      IF(RHO.GT.0.0D0) GO TO 10
      CPH=1.0D0
      SPH=0.0D0
      R=DABS(Z)
      IF(R.GT.0.0D0) GO TO 15
      CTH=1.0D0
      STH=0.0D0
      RETURN
   10 R=DSQRT(RHO+Z*Z)
      RHO=DSQRT(RHO)
      CPH=X/RHO
      SPH=Y/RHO
   15 CTH=Z/R
      STH=RHO/R
      RETURN
      END

SOURCE STATEMENTS = 19, PROGRAM SIZE = 1176 BYTES, PROGRAM NAME = POLAR    P

    NO DIAGNOSTICS GENERATED.

  [illegible] **POLAR**.
```

```
[illegible] TERM OBJECT FIXED NOT
OPT(3) LANGLVL(77) NOFIPS FLAG(I) NAME(MAIN ) LINECOUNT(55)

*....*...1.........2.........3.........4.........5.........6.........7.*....

      SUBROUTINE SPHAR
     1               (COSRTH,SINRTH,COSRPH,SINRPH,LMPC,YLJRS)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION SINRMP(9),COSRMP(9),PLMRS(45),YLJRS(81)
      COMMON/DUM6/FACTO(30),FNORM(28)
      COMPLEX*16 YLJRS
      LM=LMPC-1
      SINRMP(1)=0.D0
      COSRMP(1)=1.D0
      SINRMP(2)=SINRPH
      COSRMP(2)=COSRPH
      IF(LMPC-2    )8,8,6
6     DO 7 J=3,LMPC
      K=J-1
      SINRMP(J)=SINRPH*COSRMP(K)+COSRPH*SINRMP(K)
7     COSRMP(J)=COSRPH*COSRMP(K)-SINRPH*SINRMP(K)
8     CONTINUE
      X=COSRTH
      XA=DABS(X)
      Y=DABS(SINRTH)
      IF(XA-1.D-6) 9,9,10
9     [illegible]
      [illegible]=(L*(L+1))/2+1
      [illegible]
      [illegible]
      [illegible]
      IF([illegible]/[illegible])) 1[illegible],13,12
      [illegible]
      [illegible](J)[illegible]
      [illegible]
      [illegible]
      I[illegible]=K/2+1
      JC=(L-M)/2
      IC=JC+[illegible]
      [illegible]+M
      [illegible](J)=(((-1)**JC)*FACTO(IA))/(TAVE*FACTO(IB)*FACTO(IC))
      [illegible](M-L)15,16,16
15    M=M+1
      GO TO 11
16    IF(L-LM)17,40,40
17    L=L+1
      GO TO 13
1[illegible]   IF(XA-.[illegible]) 20,19,19
19    PLMRS(1)=1.D0
      PLMRS(2)=X
      L=2
      J=(L*(L+1))/2+1
      [illegible]
      [illegible]-1
      [illegible]
      [illegible]
      [illegible]
      [illegible](J)=([illegible]PLMRS(K)-C*PLMRS(M))/A
      [illegible]
      [illegible]
      [illegible]
      [illegible]=(L*(L+1))/2+1
      [illegible]
      [illegible](J)[illegible]
      IF([illegible]-L)25,26,26
      [illegible]+1
      [illegible]
      IF(L-LM) 27,[illegible]
27    L=L+1
      [illegible]
      PLMRS(1)=1.D0
      PLMRS(2)=X
      PLMRS(3)=Y
      PLMRS(5)=3.D0*Y*X
      L=2
      J=(L*(L+1))/2+1
      A=L
      B=2*L-1
      C=L-1
      K=J-L
      M=J-2*L+1
```

```
[illegible]                    DATE  1984 [illegible]     [illegible] 17 [illegible]
....*....1....*....2....*....3....*....4....*....5....*....6....*....7.*....
      PLMRS(J)=(B*X*PLMRS(K)-C*PLMRS(M))/A
      IF(L-LM)30,31,31
30    L=L+1
      GO TO 29
31    L=3
32    J=(L*(L+1))/2+2
      A=L-1
      B=2*L-1
      C=L
      K=J-L
      M=J-2*L+1
      PLMRS(J)=(B*X*PLMRS(K)-C*PLMRS(M))/A
      IF(L-LM) 33,34,34
33    L=L+1
      GO TO 32
34    L=2
35    M=1
      LAVE=(L*(L+1))/2+1
36    J=LAVE+M+1
      K=J-1
      N=K-1
      MAT=M
      A=(2.00*MAT*X)/Y
      B=(M+L)*(L-M+1)
      PLMRS(J)=A*PLMRS(K)-B*PLMRS(N)
      IF(M+1-L) [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
[illegible] J=[illegible]
      MAVE=L*(L+1)
      LAVE=MAVE+1
      MAVE=MAVE/2+1
      IF(J) [illegible]
[illegible] YLJRS(LAVE)=FNORM(MAVE)*PLMRS(MAVE)
      [illegible]
[illegible] JA=MAVE+J
      SAVE=FNORM(JA)*PLMRS(JA)
      MA=J+1
      IA=LAVE+J
      YLJRS(IA)=SAVE*CMPLX(COSRMP(MA), SINRMP(MA))
      IF(MOD(J,2).NE.0)YLJRS(IA)=-YLJRS(IA)
      IA=LAVE-J
      YLJRS(IA)=SAVE*CMPLX(COSRMP(MA),-SINRMP(MA))
[illegible] IF(J-L) [illegible]
[illegible] J=J+1
      GO TO [illegible]
[illegible] IF(L-[illegible]) [illegible]
[illegible] L=L+1
      [illegible]

[illegible]  PROGRAM SIZE = [illegible] BYTES, PROGRAM NAME = [illegible]

[illegible]

[illegible]
```

```
[illegible]                    VS FORTRAN                  DATE  1984 NOV 07       TIME  17 45 36

[illegible]  NOLIST NOMAP NOXREF NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOT
     OPT(0) LANGLVL(77) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

*....*...1.........2.........3.........4.........5.........6.........7.*....

       SUBROUTINE CSMINV(AM,V,NDDMST,N,MODE,IER )
       IMPLICIT REAL*8 (A-H,O-Z)
       DIMENSION AM(NDDMST,1),V(1)
       COMPLEX*16 AM,DET,CSUM,CTEMP,CDOT
       DATA CONST/3.5527136788005D-17/
       IER=0
       NMINUS=N-1
       PTEST = (1.0D0+CONST*N)**2
 1200  IF(N.NE.1) GO TO 1300
       DET=AM(1,1)
       IF( DABS(DREAL(DET))+DABS(DIMAG(DET)) .EQ. 0.0D0) GO TO 5200
       AM(1,1) = (1.0D0,0.0D0)/DET
       RETURN
 1300  DO 1309 I=1,N
       SUM=0.0D0
       DO 1310 J=1,N
       SUM = SUM +DREAL(AM(I,J))**2 +DIMAG(AM(I,J))**2
 1310  CONTINUE
       V(I)=1.0D0/SUM
 1309  CONTINUE
       DET=1.0D0
       [illegible]
       [illegible]
       [illegible]

       [illegible]
       [illegible]
       [illegible](-AM(I,K),AM(I,1),AM(1,K),KMINUS,NDDMST)
       [illegible]
       [illegible]CTEMP)**2 +DIMAG(CTEMP)**2 )
       [illegible] GO TO 20[illegible]
       [illegible]

       [illegible]
       [illegible]
       [illegible]V(K)
       [illegible] GO TO 2011
       [illegible]
       CTEMP=AM(K,J)
       AM(K,J)=AM(L,J)
       AM(L,J)=CTEMP
       CONTINUE
       VTEMP=V(L)
       V(L)=V(K)
       DET=-DET
       DET = AM(K,K)*DET
       IF([illegible]) DET=DSQRT(VTEMP)*DET
       [illegible]
       IF([illegible]) GO TO 52[illegible]
       [illegible]/AM(K,K)
       [illegible]
       [illegible] GO TO [illegible]
       [illegible]
       [illegible]T(-AM(K,J),AM(K,1),AM(1,J),KMINUS,NDDMST)
       [illegible]

       [illegible]
       [illegible]
       [illegible]
       [illegible]
       [illegible] = -AM(I,I)*CDOT(([illegible]),AM(I,K),AM(K,K),I-K,
       [illegible]
       [illegible] = [illegible](AM([illegible],I),AM(K,KPLUS),AM(KPLUS,I),I-K-1,NDDMST)
       [illegible]
       [illegible]
       [illegible]
       [illegible] I=1,N
       IF(I.[illegible].N) GO TO 4212
       [illegible] = [illegible]T(([illegible]),AM(I,K),AM(K,K),N-K+1,NDDMST)
       [illegible]
       AM(I,K) = CDOT(AM(I,K),AM(I,I+1),AM(I+1,K),N-I,NDDMST)
       CONTINUE
       CONTINUE
       [illegible] L=1,N
       K=N-L+1
       KCOL=IDINT(V(K))
       IF(KCOL.EQ.K) GO TO 4309
       DO [illegible] I=1,N
       CTEMP=AM(I,K)
       AM(I,K)=AM(I,KCOL)
```

```
[illegible]              VS FORTRAN              DATE [illegible]          TIME 17 40 56
....1.........2.........3.........4.........5.........6.........7.*....
      A(I,NCOL)=CTEMP
 4010 CONTINUE
 4005 CONTINUE
      RETURN
 5000 IER=1
      RETURN
      END
SOURCE STATEMENTS = 64, PROGRAM SIZE = 6592 BYTES, PROGRAM NAME = CSMINV
NO DIAGNOSTICS GENERATED.
COMPILATION IS ******
```

```
*....*...1.........2.........3.........4.........5.........6.........7.

      SUBROUTINE AUXIL
     1(NFAC,JCK,JSC,VK)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION YLM(31),FJ(100),FN(5)
      COMPLEX*16 YLM
      COMMON/DUMO/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VCG(50625),VM(27),VYM(243),VJ(27),VYJ(243)
     2,FM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3W(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),ICG(3)
      COMPLEX*16 CRI,VM,VYM,VYJ,FM,SM,TSAS,SAC,
     1W,AI,AF,AMMO,AEMO,S
      COMMON/DUMC/FACTO(40),FNORM(45)
      COMMON/INTCOM/LMPO,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPO,LMT,LMTPOS,
     1NSMO,MX,MXS,NMXM
      DATA PI4/ 12.566370614359/
      IF(JSC.NE.1) GO TO 18
      LM=LMPO-1
      NLM=LMPO*LMPO
      NLMM=NLM-1
      N=NSPH*NLM
      NM=N-NSPH
      NDIM=N+NM
      LMTPO=LMPO+LMPO-1
      LMT=LMTPO-1
      LMTPOS=LMTPO*LMTPO
      NSMO=NSPH-1
      MX=LM*LMPO+LMPO
      MXS=MX*MX
      NMXM=MXS*MX
      FACTO(1)=1.D0
      DO 10 I=2,NFAC
      A=I-1
   10 FACTO(I)=A*FACTO(I-1)
      DO 15 LF=1,LMTPO
      L=LF-1
      LTPO=LF+L
      DO 15 IM=1,LF
      M=IM-1
      LMM=LF-M
      LPM=LF+M
      K=LF*L/2+IM
      A=LTPO*FACTO(LMM)/FACTO(LPM)
      A=A/PI4
   15 FNORM(K)=DSQRT(A)
      DO 17 LF=1,LMPO
      L1=LF-1
      MFM=LF+L1
      M1=-LF
      DO 17 MF=1,MFM
      M1=M1+1
      DO 17 LS=1,LMPO
      L2=LS-1
      MSM=LS+L2
      M2=-LS
      LMINPO=IABS(L2-L1)+1
      LMAXPO=LS+L1
      DO 17 MS=1,MSM
      M2=M2+1
      M3=M1+M2
      DO 17 LT=LMINPO,LMAXPO
      L3=LT-1
      IF(M3.LT.-L3.OR.M3.GT.L3) GO TO 17
      IV=IND(L1,L2,L3,M1,M2,M3)
      VCG(IV)=CLGC(L1,L2,L3,M1,M2,M3)
   17 CONTINUE
   18 IF(JSC.GT.2) RETURN
      IVY=0
      IVYM=0
      DO 30 NF=1,NSMO
      NFPO=NF+1
      DO 30 NS=NFPO,NSPH
      RX=RXX(NS)-RXX(NF)
      RY=RYY(NS)-RYY(NF)
      RZ=RZZ(NS)-RZZ(NF)
      CALL POLAR(RX,RY,RZ,RR,CRTH,SRTH,CRPH,SRPH)
      CALL SPHAR(CRTH,SRTH,CRPH,SRPH,LMTPO,YLM)
      DO 20 IV=1,LMTPOS
      IVT=IV+IVY
```

```
T    NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED
       OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(55)

....*...1.........2.........3.........4.........5.........6.........7.*.

        SUBROUTINE RSM
     1          (LMPC,NGRMX,VK,JCL)
        IMPLICIT REAL*8(A-H,O-Z)
        COMMON/DUMB/ RXX(3),RYY(3),RZZ(3),RDS(3),CRI(3),
       1VCS(50625),VH(27),VYH(243),VJ(27),VYJ(243)
       2,FM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
       3W(24,2),AI(144),AF(144),AMMC(24),AEMC(24),S(24),NAME(40),IGS(3)
        COMPLEX*16 CRI,VH,VYH,VYJ,FM,SM,TSAS,SAC,
       1W,AI,AF,AMMC,AEMC,S
        DIMENSION
       1CFJ(100),FN(7),FJ(100)
        COMPLEX*16 CFJ,CRII,VKN,DCFJ,A,B,C,D
        LM=LMPC-1
        LMPT=LMPC+1
        DO 20 I=1,NGRMX
        IGSI=IGS(I)+1
        IF(IGSI.GT.I) GO TO 6
        IGSI=IGSI-1
        DO 5 L=1,LM
        FM(L,I)=FM(L,IGSI)
     5  SM(L,I)=SM(L,IGSI)
        GO TO 20
     6  VKN=VK*RDS(I)
        CRII=CRI(I)
        VKN=VKN*CRII
        CRII=CRII*CRII
        IF(DIMAG(VKN).EQ.0.0D0) GO TO 7
        CALL CBF(VKN,LMPC,JCL,CFJ)
        GO TO 9
     7  RVKN=DREAL(VKN)
        CALL RBF(RVKN,LMPC,JCL,FJ)
        DO 8 J=1,LMPT
     8  CFJ(J)=FJ(J)
     9  CALL RBF(VKR,LMPC,JCL,FJ)
        CALL RNF(VKR,LMPC,FN)
        DO 20 LD=2,LMPC
        L=LD-1
        E=LD+L
        LDPC=LD+1
        DFN=(L*FN(L)-LD*FN(LDPC))
        DFJ=(L*FJ(L)-LD*FJ(LDPC))
        DCFJ=(L*CFJ(L)-LD*CFJ(LDPC))
        A=CFJ(LD)*(VKR*DFN+FN(LD)*E)
        B=VKN*DCFJ+CFJ(LD)*E
        C=CFJ(LD)*(VKR*DFJ+FJ(LD)*E)
        D=FJ(LD)*B
        B=FN(LD)*B
        FM(L,I)=1.0D0/(1.0D0+(0.0D0,1.0D0)*((A-B)/(C-D)))
        SM(L,I)=1.0D0/(1.0D0+(0.0D0,1.0D0)*((CRII*A-B)/(CRII*C-D)))
    20  CONTINUE
        RETURN
        END
```

```
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ECT    NOLIST    MAP NOXREF   GOSTMT NODECK   SOURCE   TERM    OBJECT FIXED  NO
         OPT(0) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN  )  LINECOUNT(65)

*....*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE RLM
     1(KHELP,TH,PH,LMPC)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION YLM(26)
      COMMON/DD40/ RXX(3),RYY(3),RZZ(3),RCS(3),CFI(3),
     1VCS(50625),VH(27),VYH(243),VJ(27),VYJ(243)
     2,RMI(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3A(24,2),AI(1,4),AF(144),AMMD(24),AEMD(24),S(24),NAME(40),IOS(3)
      COMPLEX*16 CMI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1A,AI,AF,AMMD,AEMD,S
      COMMON/DDM5/FACTO(40),FNORM(45)
      COMPLEX*16 YLM,AP,AM,AZ,CL
      DATA PI4/ 12.566370614356/
      NLMP=LMPC*LMPC+1
      YLM(NLMP)=(0.0D0,0.0D0)
      IHELP=1
      IF(KHELP.EQ.2) IHELP=-1
      P=-IHELP
      COST=DCOS(TH)
      SINT=DSIN(TH)
      COSP=DCOS(PH)
      SINP=DSIN(PH)
      CALL SPHAR(COST,SINT,COSP,SINP,LMPC,YLM)
      ALPH1=-COST*COSP
      BETA1=-COST*SINP
      GAM1=SINT
      ALPH2= SINP
      BETA2=-COSP
      GAM2=0.0D0
      AP=.5*(DCMPLX(ALPH1,P*ALPH2)+DCMPLX(BETA1,P*BETA2)*(0.0D0,1.0D0))
      AM=.5*(DCMPLX(ALPH1,P*ALPH2)-DCMPLX(BETA1,P*BETA2)*(0.0D0,1.0D0))
      AZ=DCMPLX(GAM1,P*GAM2)
      DO 10 LP=2,LMPC
      L=LP-1
      LFTL=LP*L
      X=LFTL
      CL=PI4*(0.0D0,1.0D0)**L/DSQRT(X)
      MM=L+LP
      M=-LP
      DO 10 MP=1,MM
      M=M+1
      K=LFTL+M
      X=LFTL-M*(M+1)
      CP=DSQRT(X)
      X=LFTL-M*(M-1)
      CM=DSQRT(X)
      CZ=M
   10 R(M,KHELP)=DCONJG(AM*CP*YLM(K+2)+AP*CM*YLM(K)+AZ*CZ*YLM(K+1))*CL
      RETURN
      END
```

```
FECT    NOLIST    MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NO
          OPT(3) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN  )  LINECOUNT(65)

  *....*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE SZOT
     1      (IHELP,IEXP,VK,THK,PHK,VCUTN)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/GGMP/ RXX(3),RYY(3),RZZ(3),RCS(3),CHI(3),
     1VCG(50625),VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3A(24,2),AI(144),AH(144),AMMO(24),AEMO(24),S(24),NAME(40),IGG(3)
      COMPLEX*16 CHI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1A,AI,AH,AMMO,AEMO,S
      COMMON/SUMS/AM(144,144),BV(144),V(144)
      COMPLEX*16 AM,BV
      COMMON/INTCON/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
     1NSMC,NMX,NMXS,NMAM
      COMPLEX*16 CCO,GIM,GLM,SUM,SSMSP,SSESP,PHAS
      CO=0.0D0
      CCO=(0.0D0,0.0D0)
      IF(IHELP.EQ.1) GO TO 20
      ISA=2
      JSA=1
      GO TO 30
   20 ISA=1
      JSA=2
   30 IF(IEXP.NE.0)GO TO 60
      I1=0
      DO 50 N1=1,NSPH
      DO 50 L1=1,LM
      SSMSP=RM(L1,N1)
      SSESP=SM(L1,N1)
      L1TPC=L1+L1+1
      M1=-L1-1
      DO 50 IM1=1,L1TPC
      M1=M1+1
      I1=I1+1
      SUM=CCO
      I2=0
      DO 45 L2=1,LM
      L2TPC=L2+L2+1
      M2=-L2-1
      DO 45 IM2=1,L2TPC
      M2=M2+1
      I2=I2+1
   45 SUM=SUM+A(I2,JSA)*(GLM(N1,L1,M1,L2,M2)*IHELP+GIM(N1,L1,M1,L2,M2))
      IF(VCUTN.EQ.C0) GO TO 47
      SUR=DREAL(SUM)
      SUI=DIMAG(SUM)
      IF(DABS(SUR).LT.VCUTN)SUR=C0
      IF(DABS(SUI).LT.VCUTN)SUI=C0
      SUM=DCMPLX(SUR,SUI)
   47 BV(I1)=-SUM*SSMSP
   50 BV(I1+NM)=-SUM*SSESP*IHELP
      RETURN
   60 CKX=VK*DSIN(THK)*DCOS(PHK)
      CKY=VK*DSIN(THK)*DSIN(PHK)
      CKZ=VK*DCOS(THK)
      DO 70 I=1,NSPH
      IJ=(I-1)*NLMM
      PRDR=CKX*RXX(I)+CKY*RYY(I)+CKZ*RZZ(I)
      PHAS=CDEXP((0.0,1.0)*PRDR)
      K=1
      KTPC=K+K+1
      SSMSP=RM(K,I)
      SSESP=SM(K,I)
      DO 70 J=1,NLMM
      II=IJ+J
      BV(II)=-A(J,ISA)*PHAS*SSMSP
      BV(II+NM)=-A(J,ISA)*PHAS*SSESP*IHELP
      IF(J.LT.KTPC)GO TO 70
      K=K+1
      KTPC=KTPC+K+K+1
      SSMSP=RM(K,I)
      SSESP=SM(K,I)
   70 CONTINUE
      RETURN
      END
```

```
TECT    NOLIST    MAP NOXREF   GOSTMT NODECK    SOURCE   TERM    OBJECT FIXED
          OPT(0) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN   )  LINECOUNT(85)

 *....*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE SMAT
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/JUNK/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VCS(50625),VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3W(24,2),WI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),IGG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1W,WI,AF,AMMO,AEMO,S
      COMMON/JUNK5/AM(144,144),BV(144),V(144)
      COMPLEX*16 AM,BV
      COMMON/INTCOM/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
     1NSMS,NMX,NMXS,NMXM
      COMPLEX*16 GH,GK,SSMSP,SSESP,CCO,CGH,CGK
      CCO=(0.0D0,0.0D0)
      I1=0
      DO 30 N1=1,NSPH
      DO 30 L1=1,LM
      SSMSP=RM(L1,N1)
      SSESP=SM(L1,N1)
      L1TPC=L1+L1+1
      M1=-L1-1
      DO 30 IM1=1,L1TPC
      M1=M1+1
      I1=I1+1
      I2=0
      DO 28 N2=1,NSPH
      IF(N2.EQ.N1) GO TO 20
      DO 10 J=1,NLMM
      I2=I2+1
      AM(I1,I2)=CCO
      AM(I1,I2+NM)=CCO
      AM(I1+NM,I2)=CCO
   10 AM(I1+NM,I2+NM)=CCO
      GO TO 28
   20 N3L=N3CC(N1,N2,NSPH)
      DO 27 L2=1,LM
      L2TPC=L2+L2+1
      M2=-L2-1
      DO 27 IM2=1,L2TPC
      M2=M2+1
      I2=I2+1
      CGH=GH(N3L,L1,M1,L2,M2)
      CGK=GK(N3L,L1,M1,L2,M2)
      AM(I1,I2)=CGH*SSMSP
      AM(I1,I2+NM)=CGK*SSMSP
      AM(I1+NM,I2)=CGK*SSESP
      AM(I1+NM,I2+NM)=CGH*SSESP
 5555 FORMAT(3I10,2F15.6)
   27 CONTINUE
   28 CONTINUE
   30 CONTINUE
      RETURN
      END
```

```
FFECT     NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM    OBJECT FIXED  NO
            OPT(0) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN  )  LINECOUNT(85)

   *....*...1.........2.........3.........4.........5.........6.........7.*...

         SUBROUTINE CROSSE
        1(VK,IHELP,
        2SCASEC,ABSSEC,TOTSEC,VCUTA)
         IMPLICIT REAL*8(A-H,O-Z)
         COMMON/DUMD/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
        1VCG(50625),VH(27),VYH(243),VJ(27),VYJ(243)
        2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
        3A(24,2),AI(144),AE(144),AMMO(24),AEMO(24),S(24),NAME(40),ICG(3)
         COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
        1A,AI,AE,AMMO,AEMO,S
         COMMON/INTCON/LMPO,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPO,LMT,LMTPOS,
        1NSAS,NMX,NMAS,NMAX
         COMPLEX*16 GIP,GLP,AM,AE,GI,GL,SUMM,SUME,CCO,CCON,CFDET
         CO=0.0D0
         CCO=(0.0D0,0.0D0)
         CK=.5/(VK*VK)
         CCON=-(0.0D0,1.0D0)*(.5*CK/VK)
         IF(IHELP.EQ.-1) GO TO 10
         ISA=1
         JSA=2
         GO TO 12
      10 ISA=2
         JSA=1
      12 I1=0
         DO 20 L1=1,LM
         L1TPO=L1+L1+1
         M1=-L1-1
         DO 20 IM1=1,L1TPO
         M1=M1+1
         I1=I1+1
         I2=0
         SUMM=CCO
         SUME=CCO
         DO 15 N2=1,NSPH
         DO 15 L2=1,LM
         L2TPO=L2+L2+1
         M2=-L2-1
         DO 15 IM2=1,L2TPO
         M2=M2+1
         I2=I2+1
         AM=AI(I2)
         AE=AI(I2+NM)
         GI=GIP(L1,M1,N2,L2,M2)
         GL=GLP(L1,M1,N2,L2,M2)
         SUMM=SUMM+AM*GI+AE*GL
      15 SUME=SUME+AM*GL+AE*GI
         AMMO(I1)=SUMM
      20 AEMO(I1)=SUME
         IF(VCUTA.EQ.CO) GO TO 27
         DO 25 I=1,NLMM
         AMR=DREAL(AMMO(I))
         AMI=DIMAG(AMMO(I))
         AER=DREAL(AEMO(I))
         AEI=DIMAG(AEMO(I))
         IF(DABS(AMR).LT.VCUTA)AMR=CO
         IF(DABS(AMI).LT.VCUTA)AMI=CO
         IF(DABS(AER).LT.VCUTA)AER=CO
         IF(DABS(AEI).LT.VCUTA)AEI=CO
         AMMO(I)=DCMPLX(AMR,AMI)
      25 AEMO(I)=DCMPLX(AER,AEI)
      27 SUMM=CCO
         SUME=CCO
         CFDET=CCO
         DO 30 I=1,NLMM
         AM=AMMO(I)
         AE=AEMO(I)
         GI=DCONJG(AM)
         GL=DCONJG(AE)
         SUMM=SUMM+GI*AM+GL*AE
         CFDET=CFDET+DCONJG(A(I,JSA))*(AM-IHELP*AE)
      30 SUME=SUME+DCONJG(A(I,ISA))*(AM+IHELP*AE)
         SCASEC=CK*DREAL(SUMM)
         TOTSEC=-CK*DREAL(SUME)
         ABSSEC=TOTSEC-SCASEC
         SAC(ISA,ISA)=SUME*CCON
         SAC(JSA,ISA)=CFDET*CCON
         RETURN
         END
```

```
      JJ=1
      WRITE(IW,8360)
      IF(JTN.LE.1) GO TO 335
      DO 330 I=1,NLNM
  330 S(I)=A  (I)
      GO TO 2
  335 DO 340 I=1,NLNM
      II=I+1
  340 S(I)=AF(II+  )
      GO TO 2
  350 I =I +NL
  355 WRITE(IW,8  0)
      IF(JI  .  .  1) GO TO 37
  3   JTN=
      GO TO 26
  37  [illegible]
      IF(  I   .  ) GO T
      [illegible]
      GO TO 3
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      IF(    .  .1)    (I  ,ISA)=  (JSA,JSA)
      [illegible]  (IS  ,IS  ))/  (I  (I  ,I  ))
      [illegible]  (I  ,  ))/  (I  (ISA,ISA))
      [illegible]
      [illegible]
      [illegible]
      [illegible]  ,JS ,IS ,SAC(JSA,ISA)
      [illegible]  ,IS ,A  
      [illegible]
      [illegible]  (J  ,J  ))-  (SAC(IS ,ISA)))/DREAL(SAC(JSA,JSA
     1))
      [illegible]  (J  ,J  ))-  (SAC(IS ,ISA)))/DIMAG(SAC(JSA,JSA
     1))
      WRITE(IW,   )JSA,ISA,  ,JSA,ISA,  
  [illegible]
      [illegible]
[illegible]
```

```
      WRITE(IW,5000)NAME
      WRITE(IW,5500)TOL,MAXIT,CF
  140 ITER=-1
      DO 145 K=1,NDIM
  145 AI(K)=SV(K)
      IF(ICOMPX.EQ.0) GO TO 170
  147 DO 148 I=1,NDIM
      DO 148 J=1,NDIM
      AMR=REAL(AM(I,J))
      AMI=AIMAG(AM(I,J))
      IF(ABS(AMR).LT.VOUTM)AMR=0.0
      IF(ABS(AMI).LT.VOUTM)AMI=0.0
  148 AM(I,J)=CMPLX(AMR,AMI)
      GO TO 170
  150 DO 160 K=1,NDIM
  160 AI(K)=AI(K)*CT+AF(K)*CF
  170 IF(ICOMPX.EQ.0) GO TO 175
      DO 172 I=1,NDIM
      AIR=REAL(AI(I))
      AII=AIMAG(AI(I))
      IF(ABS(AIR).LT.VOUTA)AIR=0.0
      IF(ABS(AII).LT.VOUTA)AII=0.0
  172 AI(I)=CMPLX(AIR,AII)
  175 DO 190 I=1,NDIM
      DET=BV(I)
      DO 180 J=1,NDIM
  180 DET=DET-AM(I,J)*AI(J)
      IF(VOUTA.EQ.0.0) GO TO 190
      DETR=REAL(DET)
      DETI=AIMAG(DET)
      IF(ABS(DETR).LT.VOUTA)DETR=0.0
      IF(ABS(DETI).LT.VOUTA)DETI=0.0
      DET=CMPLX(DETR,DETI)
  190 AF(I)=DET
      ITER=ITER+1
      IF(ITER.LE.1) OLSEC=SEC
      CALL CPUSEC(VR,IMPLP,SCASEC,ADDSEC,TOTSEC,VOUTA)
      SEC=TOTSEC
      IF(ITER.LE.0) GO TO 150
      DELTA=OLSEC/SEC-1.0D0
      IF(IPR.EQ.1)WRITE(IW,6000)ITER,OLSEC,SEC,DELTA
      IF(ABS(DELTA).LT.TOL)GO TO 200
      IF(ITER.LT.MAXIT)GO TO 150
      GO TO 200
  200 IF(JOB.EQ.4) CALL SMAT
      DO 205 I=1,NDIM
  205 AM(I,I)=AM(I,I)+1.0
      CALL CSTINV(AM,V,NOBEST,NDIM,[illegible],IER,VOUTM)
      IF(IER.EQ.1) GO TO 230
      DO 210 I=1,NDIM
      DET=0.0
      DO 208 J=1,NDIM
  208 DET=DET+AM(I,J)*BV(J)
  210 AF(I)=DET
      CALL CPUSEC(VK,IMPLP,SCASEC,ADDSEC,TOTSEC,VOUTA)
  230 WRITE(IW,6100)NAME
      IK=0
      IF(IK-NA)270,260,250
  250 JIN=1
  260 DO 290 J=JIN,NSPH
      JJ=J
      IF(JJ.EQ.1) GO TO 275
      DO 270 I=1,NLEN
  270 S(I)=[illegible](I)
      GO TO 285
  275 DO 280 I=1,NLEN
      II=I+IK
  280 S(I)=AF(II)
  285 WRITE(IW,6010)
      IF(JJ.EQ.0) GO TO 290
      WRITE(IW,6070)
      GO TO 300
  290 WRITE(IW,6020)
  300 WRITE(IW,6050)
      IF(JI.NE.1) GO TO 310
      WRITE(IW,6060)
      GO TO 320
  310 WRITE(IW,6040)J
  320 WRITE(IW,6050)(S(I),I=1,NLEN)
      IF(JJ.EQ.1) GO TO 350
```

```
      WRITE(IW,5015)VR,THR,PHR
      WRITE(I ,  10)[illegible]
      READ(I ,5   )SI,ISL
      READ(I ,5   )VCOTR,VCOTA,VCOTR
      THR=THR*PI0/180.
      PHR=PHR*PI0/180.
      NHELP=
11    IF(IHELP)110,115,117
110   JHELP=1
      ISA=1
      JSA=2
      GO TO 11
11    IHELP=-1
      ISA=2
      JSA=1
11    IHELP=JHELP
      GO TO 117
115   IHELP=-JHELP
      IHELP=1
      GO TO 1
117   [illegible]
      [illegible]
      [illegible]
      CALL [illegible](  ,JSA,JSA,VR)
1     IF([illegible].IHELP.EQ.1) GO TO 125
      [illegible]=1.
12    CALL [illegible](IHELP,I[illegible],ERRC)
12    IF([illegible]) GO TO 14
      CALL [illegible](    ,[illegible],JSA)
      CALL [illegible]
     1 [illegible](I,  J),K =1,  ),K =1, I )
      [illegible]
      [illegible]
      [illegible])*(  COSI/VR)
      [illegible]
      [illegible]=0
      [illegible]
      [illegible]=
      ISAS(ISA,ISA)=[illegible]
      ISAS(JSA,ISA)=[illegible]
      [illegible]=
      [illegible]=1,  )
      IF([illegible]) IC I=IC I+1
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]=0
      DO 137 L=1,
      LTR=L+L+1
      DO 137 IR=1,LTR
      =K+1
      A=-A( ,ISA)*  (L,  )
      B=-A( ,ISA)*  (L,  )
      [illegible]=[illegible]+[illegible]( )**2+[illegible]( )**2
      [illegible]=[illegible]+[illegible](A( ,JSA))*(A-B)
137   [illegible]=[illegible]+[illegible](A( ,ISA))*(A+ )
      [illegible]=[illegible]*[illegible]ST
      TOTS  =-[illegible]( )*[illegible]
      ABS   =TOTS  -[illegible]
      [illegible]=[illegible]+[illegible]
      TOS=TOS+TOTS
      ACS=ACS+A[illegible]
      [illegible]=[illegible]/[illegible]
      [illegible]=T[illegible]/[illegible]SS
      [illegible]=A[illegible]/[illegible]
      ISAS(ISA,ISA)=ISAS(ISA,ISA)+ [illegible]
      ISAS(JSA,ISA)=ISAS(ISA,JSA)+[illegible]
      IF(IW   .NE.1) GO TO 140
      WRITE(IW,[illegible])[illegible]
      WRITE(IW,[illegible])[illegible]
      WRITE(IW,61  )SCA[illegible],A SSEC,TOTS C
      WRITE(IW,7400)[illegible],[illegible],[illegible]
140   CONTINUE
      IF(  SS.EQ.1) WRITE(IW,670 )
     1ISA,ISA,ISAS(ISA,ISA),JSA,ISA,ISAS(JSA,ISA)
142   CALL [illegible](IHELP,IEXP,VR,THR,PHR,VCOT )
      IF(I  .NE.  ) GO TO 20
      IF(IWIP.NE. ) GO TO 143
```

```
REPORT NO. - [illegible]    I C C F    L I B R A R Y    F I L E    M A I N T E N A N [illegible]
....+....1....15....2....25....3....35....4....45....5....55....6....65....7....75....8

      IMPLICIT REAL*8(A-H,O-Z)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CCC                                                                   CCC
CCC                          PRG 2                                    CCC
CCC                                                                   CCC
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      COMMON /[illegible]/ HXX(3),HYY(3),HZZ(3),[illegible](3),CHI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,[illegible](4,3),[illegible](4,3),TGAS(2,2),SAC(2,2),
     3[illegible](24,[illegible]),[illegible]I(144),[illegible](144),A[illegible](24),[illegible](24),S(24),NAME(40),I[illegible](3)
      COMPLEX*16 CHI,VH,VYH,VYJ,[illegible],[illegible],TGAS,SAC,
     1[illegible],AI,[illegible],[illegible],[illegible],S
      COMMON /[illegible]B/A(144,144),BV(144),V(144)
      COMPLEX*16 A,BV,V
      COMMON /[illegible]/FACT(40),FNORM(40)
      COMMON /INFOUT/[illegible],LM,NEM,NEMM,NMM,NDIM,NSPH,LMTPO,LMT,LMTPOS,
     1[illegible],[illegible],RAD,[illegible]X
      COMPLEX*16 CCC,SET,A,B,CHSET,CCCN
      DATA PI/3.14159265358979/
 5000 FORMAT(4I2)
 5010 FORMAT(3D20.0)
 5015 FORMAT(D20.0,2F10.4)
 [illegible] FORMAT(10I5)
 5025 FORMAT([illegible]D20.5)
 [illegible] FORMAT(2[illegible]D20.0)
 [illegible] FORMAT(20A4)
 [illegible] FORMAT(1H ,////,1H ,[illegible]X,20A4,/,1H ,[illegible]X,20A4,////)
 [illegible] FORMAT(1H1,1[illegible]X,'CALCULATIONS [illegible] REFER TO DATASET ',5A4,///)
 [illegible] FORMAT(1H ,[illegible],[illegible]LITUDES [illegible])
 [illegible] FORMAT(1H+,[illegible],[illegible]TIO)
 [illegible] FORMAT(1H+,[illegible],15H MULTIPOLE [illegible] )
 [illegible] FORMAT(1H+,[illegible],7H[illegible] ,I2,/)
 [illegible] FORMAT(4(2X,D15.7))
 [illegible] FORMAT(1H ,/)
 [illegible] FORMAT(1H+,[illegible],[illegible]ELECT[illegible])
 [illegible] FORMAT(1H ,//)
 [illegible] FORMAT(1H+,[illegible]X,[illegible],/)
 [illegible] FORMAT(1H ,[illegible]X,7HSCASEC=,D15.7,3X,7HABSSEC=,D15.7,3X,7HTOTSEC=,
     1D15.7,///)
 [illegible] FORMAT(1H ,[illegible]X,'CROSS SECTIONS OF SPHERE ',I2,/)
 [illegible] FORMAT(1H ,[illegible]X,7H[illegible]T=,D15.7,3X,7HABS[illegible]AT=,D15.7,3X,7H[illegible]AT=,
     1D15.7,///)
 [illegible] FORMAT(1H ,[illegible]X,7H[illegible]=,D15.7,3X,7H[illegible]SS=,D15.7,3X,7H[illegible]=,
     1D15.7,///)
 [illegible] FORMAT(1H ,1[illegible]X,'IT[illegible]                     [illegible]SEC                     NASEC
     1[illegible]            ( TOL=',D10.3,',  MAXIT=',I2,',  CI=',D10.3,1H),///)
 [illegible] FORMAT(1H ,I[illegible],I[illegible],[illegible])
 67[illegible] FORMAT(1H ,I[illegible]X,[illegible](1[illegible]X,2I1,3X,2[illegible]))
 [illegible] FORMAT(1H ,I[illegible]X,[illegible](1[illegible]X,2I1,3X,D2[illegible]))
      I[illegible]=[illegible]
      I[illegible]=[illegible]
      [illegible] ([illegible],[illegible])IDATA,JDATA,KDATA
      [illegible]([illegible],[illegible])
      WRITE ([illegible],[illegible])IDATA,JDATA,KDATA
      READ(I[illegible],[illegible])[illegible]CAL
      DO [illegible] [illegible]CAL=1,[illegible]CAL
      [illegible](I[illegible],[illegible])[illegible]
      READ(I[illegible],[illegible])J[illegible],IW[illegible],IWCSS,IWCIF
CCC
CCC     I[illegible] [illegible] CHANGE EM SET JS =1.
CCC     I[illegible] CHANGE VH SET J[illegible]=[illegible].
CCC     I[illegible] [illegible] CHI SET JS[illegible]=[illegible].
CCC     I[illegible] [illegible] I[illegible]ELP [illegible] THE [illegible] PHA SET JS[illegible]=4.
CCC
CCC     I[illegible] [illegible] [illegible] MULTIPOLAR EXPANSION COEFFICIENT IS WRITTEN.
CCC
CCC     IF IW[illegible] [illegible] MULTIPOLAR EXPANSION COEFFICIENTS
CCC     [illegible] ARE ALSO WRITTEN.
CCC
CCC     IF IWCSS=1 [illegible] SECTIONS OF THE SINGLE SPHERES ARE WRITTEN.
CCC
CCC     IF IWCIF=1 DATA ABOUT CONVERGENCE OF ITERATIVE
CCC     [illegible]CEDURE ARE WRITTEN.
CCC
      IF(JS[illegible].[illegible].4) GO TO [illegible]
      READ(IR,[illegible])NSPH,LMP[illegible],IHELP,IEXP,MAXIT,NFAC,JCK,JCL
      READ(IR,5015)(HXX(I),HYY(I),HZZ(I),I=1,NSPH)
      READ(IR,[illegible])(I[illegible](I),I=1,NSPH)
      READ(IR,5010)([illegible](I),I=1,NSPH)
      [illegible](IR,[illegible])([illegible](I),I=1,NSPH)
```

CARD 13 (2E20.8)

CI	Mixing factor for the iterative inversion of the T-matrix. The value CI=0.5 ensures good convergence.
TOL	Tolerance of the inverted T-matrix. In practice $T*T^{-1} \leq$ TOL.

These quantities need be specified only when INVER=0.

CARD 14

VCUTM	The elements of the T-matrix with magnitude smaller than this parameter are set to zero.
VCUTA	The multipolar amplitudes of the scattered wave smaller than this value are set to zero.
VCUTN	The multipolar amplitudes of the incident plane wave smaller than this value are set to zero.

The three quantities above are usually set to 1.0E-36, a value that prevents the occurrence of program interrupts due to underflow.

MAXIT	Number of the iterations if the T-matrix is to be inverted iteratively.
NFAC	Maximum value of the factorials to be used in the normalization factors.
JCK JCL	Dimension of the vector of the Bessel functions.

<u>CARD 7</u> (3E20.8) (NSPH card)

RXX(I) RYY(I) RZZ(I)	Cartesian coordinates of the centre of the I-th sphere in the cluster.

<u>CARD 8</u> (40I2)

IOG(I)	This index specifies the type of the I-th sphere in the cluster. If IOG(I+1)=IOG(I) the program does not recalculate the T-matrices for the I+1-th sphere but assume they are identical to those of the I-th sphere.

<u>CARD 9</u> (3E20.8)

ROS(I)	Radius of the I-th sphere.

<u>CARD 10</u> (2E20.8) (NSPH card)

CRI(I)	Complex refractive index of the I-th sphere.

<u>CARD 11</u> (E20.8, 2F10.4)

VK	Magnitude of the wavevector of the incident wave
THK PHK	Polar angles (in Degrees) of the incident wavevector.

<u>CARD 12</u> (3I5)

INVER	0 the T-matrix is inverted iteratively. 1 the T-matrix is inverted by LU factorization.
MODE	0, 1, 2, 3. This parameter provides the equilibration of the T-matrix in four different modes. The value MODE=3 has proved to be the most suitable for dielectric clusters far from resonance.
NDDMST	Maximum dimension of the T-matrix. <u>must</u> be equal to the dimension of the matrix AM.

PRG2 and PRG3

These programs were written at the CRDC by F.Borghese, P.Denti and R.Saija in order to handle relatively big clusters (see Table I), even at the cost of increasing the CPU time. PRG3 differs from PRG2 in that it does not require the storage of the Clebsch-Gordan coefficients.

INPUT DESCRIPTION

Refer to DATASET TEST001.

CARD 1 (3A4)

IDATA JDATA KDATA	These quantities identify the DATASET. They can be left blank if desired.

CARD 2 blank

CARD 3 (I2)

NCAL	Number of the group of data within the DATASET.

CARD 4 (40A4) (2 cards)

NAME	This heading identifies the output. Any alphameric character can be used.

CARD 5 (4I2)

JGO IWMA IWCSS IWCIP	These quantities control the input and output operations of PRG2 and PRG3. Their meaning is explained in the comment cards within the programs. Note that if JGO is put equal to 1 for all groups of data the programs run properly but for that they recompute matrices whose elements have still valid values.

CARD 6 (8I2)

NSPH	Number of the spheres in the cluster.
LMPO	L_M+1
IHELP	Helicity of the incident plane wave. Use +1 for right helicity and -1 for left helicity.
IEXP	This quantity was originally introduced to control the convergency of the multipolar expansions. Set it to 0.

```
                                                  DATE  1984 NOV 07       TIME  17

                         OPTIONS IN EFFECT:  SOURCE   TERM   OBJECT FIXED  NOT
                         LANGLVL(77) NOFIPS   FLAG(I)   NAME(MAIN  )  LINECOUNT(85)

       *....*...1.........2.........3.........4.........5.........6.........7.*....

                 COMPLEX FUNCTION CDOT*16(Z,A,B,N,ISTEP)
                 COMPLEX*16 Z,A(1),B(1)
                 CDOT=Z
                 IF(N) 4,4,2
           2     DO 3 J=1,N
           3     CDOT=CDOT+A(1+(J-1)*ISTEP)*B(J)
           4     RETURN
                 END
S*    SOURCE STATEMENTS = 8, PROGRAM SIZE = 934 BYTES, PROGRAM NAME = CDOT     PAGE
CS*     NO DIAGNOSTICS GENERATED.
  OF COMPILATION 15 ******
```

```
*....*...1.........2.........3.........4.........5.........6.........7.*..
   20 VYH(IVT)=DCONJG(YLM(IV))
      IVY=IVY+LMTPOS
      ARG=FR*VK
      CALL RBF(ARG,LMT,JCK,FJ)
      CALL RNF(ARG,LMT,FN)
      DO 25 IV=1,LMTPO
      IVT=IV+IVHB
   25 VH(IVT)=DCMPLX(FJ(IV),FN(IV))
      IVHB=IVHB+LMTPO
   30 CONTINUE
      IVY=0
      IVHB=0
      CC=0.0D0
      DO 55 NF=1,NSPH
      RX=-RXX(NF)
      RY=-RYY(NF)
      RZ=-RZZ(NF)
      IF(RX.EQ.CC.AND.RY.EQ.CC.AND.RZ.EQ.CC) GO TO 50
      CALL POLAR(RX,RY,RZ,RR,CRTH,SRTH,CRPH,SRPH)
      CALL SPHAR(CRTH,SRTH,CRPH,SRPH,LMTPO,YLM)
      DO 40 IV=1,LMTPOS
      IVT=IV+IVY
   40 VYJ(IVT)=DCONJG(YLM(IV))
      ARG=RR*VK
      CALL RBF(ARG,LMT,JCK,FJ)
      DO 45 IV=1,LMTPO
      IVT=IV+IVHB
   45 VJ(IVT)=FJ(IV)
   50 IVY=IVY+LMTPOS
   55 IVHB=IVHB+LMTPO
      RETURN
      END
```

```
5.0 (MAY 1983)                VS FORTRAN              DATE  1984 NOV 07      TIME  [illegible]
LIN ERR CT    NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIX
          OPT(0) LANGLVL(66) NOFIPS   FLAG(I)   NAME(MAIN  )  LINECOUNT(6
     ....*...1.........2.........3.........4.........5.........6.........7..
            COMPLEX FUNCTION CH#1S(NEL,L1,M1,L2,M2)
            IMPLICIT REAL*8(A-H,O-Z)
            COMMON /DOUB/ AXX(3),AYY(3),AZZ(3),AOS(3),CHI(3),
           1VOB(3,[illegible]),VM(27),VYM(243),VJ(27),VYJ(243)
           2,[illegible](4,3),S[illegible](4,3),ISAS(2,2),SAC(2,2),
           3A(24,3),AI(144),A[illegible](144),[illegible](24),A[illegible](24),S(24),NAME(40),IOB(3)
            COMPLEX*16 CHI,VM,VYM,VYJ,AM,SM,ISAS,SAC,
           1A,AI,A[illegible],A[illegible],[illegible],S
            COMMON /INTG/ [illegible],LN,NLN,NLNN,N,NY,NJIN,NSPH,LMIPL,LMT,LMTPLS,
           1[illegible]
            COMPLEX*16 CSUM,CGG,CFCN
            DATA PI4/12.566370614359/
            CGG=(0.D0,0.D0)
            CH=CGG
            L1PL=L1+1
            L[illegible]=IABS(L2-L1)+1
            L[illegible]=L2+L1PL
            C[illegible]=PI4*(L1+L1PL)*(L2+L2+1)
            CC[illegible]=DSQRT(C[illegible])
            ISN=1
            IF(L2.GT.L1.AND.MOD(LMIN[illegible],2).EQ.0) ISN=-ISN
            IF(MOD(M2,2).NE.0) ISN=-ISN
            IF(N[illegible]L.LT.0) GO TO 22
            NEL[illegible]=NEL-1
            GO TO 23
        22  N[illegible]L[illegible]=-NEL-1
        23  [illegible]=N[illegible]L[illegible]+LMT[illegible]
            [illegible]Y=[illegible]L[illegible]LMTPLS
            [illegible] J[illegible]=1,[illegible]
            CSUM=CGG
            [illegible]=[illegible]
            [illegible]=[illegible]+[illegible]
            [illegible]=[illegible]+[illegible]
            [illegible]I.[illegible]-[illegible].[illegible]1.GT.L1.[illegible].[illegible]2.LT.-L2.OR.[illegible]UPM2.GT.L2)
           [illegible]
            [illegible]=[illegible]
            [illegible]=I[illegible](L[illegible],L[illegible],[illegible],-[illegible],[illegible]1,[illegible]1)
            [illegible]=I[illegible](L[illegible],L[illegible],[illegible],-[illegible],[illegible]2,[illegible]2)
            [illegible]=VO[illegible](I[illegible]1)-VO[illegible](I[illegible]2)
        [illegible] [illegible](I[illegible]).[illegible]15.[illegible])
            [illegible]LT=L[illegible],[illegible]
            L3=LT-1
            [illegible]=[illegible]-[illegible]
            IF([illegible].LT.-L3.OR.[illegible]2.GT.L3) GO TO 40
            [illegible]Y=L3[illegible]+L[illegible]+[illegible]2
            A[illegible]=L3+LT
            [illegible]=I[illegible](L[illegible],L1,L3,[illegible],0,0)
            I[illegible]=I[illegible](L[illegible],L1,L3,[illegible]2,-[illegible]1,[illegible]2-[illegible]1)
            [illegible]=[illegible]*V[illegible]([illegible]+LT)*VYH(N[illegible]Y+[illegible]Y)*VOB(IND3)*VOB(IND4)/DSQRT(ACF3)
            IF([illegible].GT.0) GO TO 35
            IF([illegible](L[illegible],2).[illegible].0) CFCN=-CFCN
        35  CSUM=CSUM+CFCN
        40  [illegible]
            CS[illegible]=CSUM*CH
            IF([illegible].[illegible].0) CSUM=-CSUM
        50  [illegible]=[illegible]+CSU[illegible]
            CH=CH*CCH
            RETURN
            END
```

```
IN EFFECT    NOLIST   MAP NOXREF   NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NO
               OPT(3) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN  )  LINECOUNT(55)

      *....*...1.........2.........3.........4.........5.........6.........7.*...

            COMPLEX FUNCTION GK*16(APL,L1,M1,L2,M2)
            IMPLICIT REAL*8(A-H,O-Z)
            COMMON /GORD/ AXX(3),AYY(3),AZZ(3),ACS(3),CHI(3),
           1VCG(5,125),VM(27),VYM(243),VJ(27),VYJ(243)
           2,RM(4,3),SM(4,3),ISAS(2,2),SAC(2,2),
           3,L(24,2),LI(144),AI(144),AMP(24),AEXP(24),S(24),NAME(40),ICS(3)
            COMPLEX*16 CHI,VM,VYM,VYJ,RM,SM,ISAS,SAC,
           1[illegible]
            COMMON /INTGR/ [illegible],LM,NCM,[illegible],N,NM,[illegible],NSPH,LMIPO,LMI,LMTPO,
           1[illegible]
            COMPLEX*16 CUR,CSCR,CUT,CCI,CFUN
            DATA PI/3.14159265358979D0/
            CUR=(1.0D0,0.0D0)
            CCI=(0.0D0,1.0D0)
            GK=[illegible]
            L1M1=L1-1
            L1P1=L1+1
            LMIN [illegible]=IABS(L2-L1M1)+1
            LMAX[illegible]=L2+L1
            GR=PI*4*(L1+L1[illegible])*(L1+L1PO)*(L2+L2+1)/L1PO
            CC[illegible]=DSQRT(GR)*CCI
            ISN=1
            IF([illegible].EQ.[illegible].AND.MOD(LMINPO,2).EQ.0) ISN=-ISN
            IF(MOD(M2,2).NE.0) ISN=-ISN
            IF([illegible].LT.0) GO TO 22
            [illegible]=[illegible]-1
            [illegible]
     22     [illegible]=-[illegible]-1
     23     [illegible]=[illegible]
            [illegible]
            [illegible]
            [illegible]
            [illegible]
            [illegible]=[illegible]+1
            [illegible]=[illegible]+1
            IF([illegible].LT.-L1[illegible].OR.MUPM1.GT.L1[illegible].OR.MUPM2.LT.-L2.OR.MUPM2.GT.L2)
           [illegible]
            [illegible]=[illegible]
            I[illegible]=I[illegible](1,L1[illegible],L1,-[illegible],MUPM1,M1)
            I[illegible]=I[illegible](1,[illegible],L2,-[illegible],MUPM2,M2)
            [illegible]=[illegible](IN[illegible])*VCG(I[illegible])
            [illegible]=[illegible],[illegible],2
            [illegible]=L1-1
            [illegible]=M1-M[illegible]
            IF([illegible].LT.-[illegible].OR.M1[illegible].GT.L3) GO TO 40
            [illegible]Y=[illegible]+L[illegible]+1[illegible]
            [illegible]=[illegible]+L[illegible]
            I[illegible]=I[illegible](L[illegible],L1[illegible],L[illegible],[illegible],0,0)
            I[illegible]=I[illegible](L[illegible],L1[illegible],L3,[illegible],-[illegible]M1,M2-M1)
            [illegible]+L[illegible])*VYM([illegible]Y+[illegible]Y)*VCG(IN[illegible])*VCG(INC4)/DSQRT(A[illegible])
            [illegible]=[illegible]+[illegible]
            [illegible]=[illegible]Y+[illegible]
            IF([illegible].GT.[illegible]) [illegible]
            IF(MOD(L3,[illegible]).[illegible].0) CFUN=-CFUN
     30     [illegible]=[illegible]+CFUN
     40     [illegible]=-J[illegible]
            [illegible]
            IF([illegible].NE.0) CSUM=-CSUM
            [illegible]=[illegible]+CSU[illegible]
            GK=GK*CC
            [illegible]
            [illegible]
```

```
LEVEL 1.3.0 (MAY 1983)          VS FORTRAN          DATE  1984 NOV 07      TIME  17  [illegible]
OPTIONS IN EFFECT   NOLIST   NOMAP NOXREF   NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED
       OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(55)

     ....*...1.........2.........3.........4.........5.........6.........7.*...

      COMPLEX FUNCTION GIM*16(N1,L1,M1,L2,M2)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON/JUNC/ RXX(3),RYY(3),RZZ(3),RUS(3),CHI(3),
     1VCG(30625),VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,4),SM(4,3),ISAS(2,2),SAC(2,2),
     3A(24,3),AI(144),AT(144),AMO(24),ALMO(24),S(24),NAME(40),IGG(3)
      COMPLEX*16 CHI,VH,VYH,VYJ,RM,SM,ISAS,SAC,
     1 AI,AT,AMO,ALMO,S
      COMMON/INTG/LMPC,LM,NLM,NLMM,N,NM,NDIM,NOPH,LMTPC,LMT,LMTPC3,
     1 [illegible],NMXS,NTX
      COMPLEX*16 CSUM,CC,CFCN
      DATA PI4/12.566370614359/
      CC=(0.D0,0.D0)
      GIM=CC
      [illegible]=1.D0
      IF(RXX(N1).EQ.CC.AND.RYY(N1).EQ.CC.AND.RZZ(N1).EQ.CC) GO TO 60
      L1PC=L1+1
      LMINPC=IABS(L2-L1)+1
      LMAXPC=L2+L1PC
      CA=PI4*(L1+L1PC)*(L2+L2+1)
      CA=DSQRT(CA)
      ISN=1
      IF(L2.GT.L1.AND.MOD(LMINPC,2).EQ.0) ISN=-ISN
      IF(MOD(M1,2).NE.0) ISN=-ISN
      N1MO=N1-1
      NOJ=N1MO*LMTPC
      NOY=N1MO*LMTPC3
      DO 45 JM=1,2
      CSUM=CC
      MO=JM-1
      MOPM1=MO+M1
      MOPM2=MO+M2
      IF(MOPM1.LT.-L1.OR.MOPM1.GT.L1.OR.MOPM2.LT.-L2.OR.MOPM2.GT.L2)
     1GO TO 45
      JSN=ISN
      INO1=INO(1,L1,L1,-MO,MOPM1,M1)
      INO2=INO(2,L2,L2,-MO,MOPM2,M2)
      CA=VCG(INO1)*VCG(INO2)
      DO 40 LT=LMINPC,LMAXPC,2
      L3=LT-1
      M1MM2=M1-M2
      IF(M1MM2.LT.-L3.OR.M1MM2.GT.L3) GO TO 40
      NY=L3*L3+LT+M1MM2
      ACPS=L3+LT
      INO3=INO(L2,L1,L3,0,0,0)
      INO4=INO(L2,L1,L3,MOPM2,-MOPM1,M2-M1)
      CFCN=JSN*VJ(NOJ+LT)*VYJ(NOY+NY)*VCG(INO3)*VCG(INO4)/DSQRT(ACPS)
      CSUM=CSUM+CFCN
   40 JSN=-JSN
      CSUM=CSUM*CA
      IF(MO.NE.0) CSUM=-CSUM
   45 GIM=GIM+CSUM
      GIM=GIM*[illegible]
      RETURN
   60 IF(L1.EQ.L2.AND.M1.EQ.M2) GIM=(1.D0,0.D0)
      RETURN
      END
```

```
[illegible] 1983)                VS FORTRAN                 DATE  1984 NOV 07      TIME  17      [illegible]

DIRECT   NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED   [illegible]
            OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(60)

    *....*...1.........2.........3.........4.........5.........6.........7.*....

      COMPLEX FUNCTION [illegible]*16(N1,L1,M1,L2,M2)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /[illegible]/ RXX(3),RYY(3),RZZ(3),RCS(3),CHI(3),
     1V[illegible](5),V(27),VYH(243),VJ(27),VYJ(243)
     2,R[illegible](4,3),S[illegible](4,3),TSAS(2,2),SAC(2,2),
     3[illegible](4,2),AI(144),AP(144),AM[illegible](24),AE[illegible](24),S(24),NAME(40),IGO(2)
      [illegible] CHI,VH,VYH,VYJ,RY,SY,TSAS,SAC,
     1[illegible],I[illegible],A[illegible]
      COMMON /INIT[illegible]/EMPC,EM,NEM,[illegible],NDIM,NSPH,EMIPC,LMT,LMTPC3,
     1[illegible],NAS,[illegible]
      [illegible] CC,CSUM,CCT,CCI,CFUN
      DATA FPI/12.566370614359[illegible]/
      CC[illegible]=([illegible],[illegible])
      CC[illegible]=CC[illegible]
      [illegible]=[illegible]
      IF(RXX(N1).EQ.0D0.AND.RYY(N1).EQ.0D0.AND.RZZ(N1).EQ.0D0) RETURN
      CCI=(0.D0,1.D0)
      L1MO=L1-1
      L1PO=L1+1
      L[illegible]=IABS(L2-L1PO)+1
      LMAXP =L2+L1
      C=FPI*(L1+L1PO)*(L1+L1PO)*(L2+L2+1)/L1PO
      CC=DSQRT(C)*CCI
      ISN=1
      IF(L[illegible].GT.L1 [illegible].[illegible]MOD(LMI[illegible]PO,2).EQ.0) ISN=-ISN
      IF(MOD([illegible],2).EQ.0) ISN=-ISN
      [illegible]=N1-1
      [illegible]J=[illegible]*LMT[illegible]
      [illegible]=N1[illegible]*LMTPC[illegible]
      DO [illegible] J=1,3
      C[illegible]=[illegible]
      [illegible]=J-[illegible]
      [illegible]I=[illegible]+[illegible]
      [illegible]=[illegible]+[illegible]
      IF([illegible].LT.-L1 [illegible].[illegible].GT.L1 [illegible].[illegible].LT.-L2.[illegible].GT.L2)
      [illegible]
      [illegible]=1[illegible]
      [illegible]1=I[illegible](1,L1M[illegible],L1,-M[illegible],M[illegible]1,M1)
      [illegible]=I[illegible](1,L[illegible],L2,-[illegible],[illegible]2,M2)
      [illegible]=[illegible](IND1)*[illegible](IN[illegible])
      DO [illegible] LI=L[illegible],LMAX[illegible]
      [illegible]=LI-[illegible]
      [illegible]=[illegible]-[illegible]
      IF([illegible].LT.-L[illegible].[illegible].GT.L[illegible]) GO TO 40
      [illegible]=L[illegible]+LI+N[illegible]
      [illegible]=[illegible]+LI
      [illegible]=I[illegible](L2,L1[illegible],L[illegible],[illegible])
      I[illegible]=I[illegible](L[illegible],L1[illegible],L[illegible],[illegible],-[illegible],M2-M1)
      [illegible]=[illegible]V[illegible]([illegible]J+LI)*VYJ(N[illegible]+[illegible])*V[illegible](IND3)*V[illegible](IN[illegible])/DS[illegible]RT(ALFS)
      [illegible]=[illegible]+CFUN
   40 [illegible]=-[illegible]
      [illegible]=[illegible]
      IF([illegible].[illegible]) [illegible]SUM=-CSUM
   50 [illegible]=[illegible]+CSUM
      [illegible]=[illegible]*CC[illegible]
      RETURN
      END
```

```
[illegible]      NOLIST    NOMAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED
                 OPT(0) LANGLVL(77) NOFIPS   FLAG(I)   NAME(MAIN  )  LINECOUNT(55)

      *....*...1.........2.........3.........4.........5.........6.........7.*..

            COMPLEX FUNCTION CIP*16(L1,M1,N2,L2,M2)
            IMPLICIT REAL*8(A-H,O-Z)
            COMMON /[illegible]/ RXX(3),RYY(3),RZZ(3),RCS(3),CPI(3),
           1VCS([illegible]),VY(27),VYP(243),VJ(27),VYJ(243)
           2,[illegible](4,3),SY(4,3),TSAS(2,2),SAC(2,2),
           3[illegible](4,2),AI(144),AF(144),AMM[illegible](24),AMMC(24),S(24),NAME(40),[illegible](3)
            COMPLEX*16 CPI,VY,VYP,VYJ,XY,SY,TSAS,SAC,
           1[illegible],AI,AF,AMM[illegible],AMMC,S
            COMMON /INTCOM/ [illegible],LM,NLM,NLMM,N,NM,NDIM,NJPM,LMTPC,LMT,LMTPCS,
           1[illegible]
            COMPLEX*16 CSUM,CC,CFUN
            DATA PI4/12.566370614359/
            CC0=(0.0D0,0.0D0)
            CIP=CC0
            [illegible]=0.0D0
            IF(RXX(N2).EQ.0.0.AND.RYY(N2).EQ.0.0.AND.RZZ(N2).EQ.0.0) GO TO 60
            L1P1=L1+1
            LMINPC=IABS(L2-L1)+1
            LMAXPC=L2+L1P1
            CF=PI4*(L1+L1P1)*(L2+L2+1)
            CSF=DSQRT(CF)
            ISN=1
            IF(L2.GT.L1.AND.MOD(LMINPC,2).EQ.0) ISN=-ISN
            IF(MOD(M1,2).NE.0) ISN=-ISN
            [illegible] = [illegible]-1
            [illegible]
            [illegible]
            DO 50 J=1,[illegible]
            [illegible]
            [illegible]
            [illegible]=[illegible]+[illegible]
            [illegible]=[illegible]+[illegible]
            IF([illegible].LT.-L1.[illegible].GT.L1.[illegible].LT.-L2.OR.[illegible].GT.L2)
        10  [illegible]
            [illegible]=ISN
            [illegible]=I[illegible](1,L1,L1,-[illegible],[illegible],[illegible])
            [illegible]=I[illegible](1,[illegible],L2,-[illegible],[illegible],[illegible])
            [illegible]=VCS(I[illegible])*VCS(I[illegible])
            DO 40 LT=LMINPC,LMAXPC,2
            [illegible]
            [illegible]=[illegible]-[illegible]
            IF([illegible].LT.-L3.OR.[illegible].GT.L3) GO TO 40
            [illegible]
            [illegible]=L[illegible]+L[illegible]
            [illegible]=I[illegible](L2,L1,L3,0,0,0)
            [illegible]=I[illegible](L2,L1,L3,[illegible],-[illegible],[illegible]-[illegible])
            CFUN=J[illegible]*VJ([illegible]+LT)*VYJ([illegible])*VCS(I[illegible])*VCS(I[illegible])/DSQRT(A[illegible])
            IF([illegible](L3,2).NE.0) CFUN=-CFUN
            CSUM=CSUM+CFUN
        40  JSN=-JSN
            CSUM=CSUM*C[illegible]
            IF([illegible].NE.0) CSUM=-CSUM
        50  CIP=CIP+CSUM
            CIP=CIP*CC[illegible]
            RETURN
        60  IF(L1.EQ.L2.AND.M1.EQ.M2) CIP=(1.0D0,0.0D0)
            RETURN
            END
```

```
   *....*...1.........2.........3.........4.........5.........6.........7.*...

      COMPLEX FUNCTION CLP*16(L1,M1,N2,L2,M2)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/ROMC/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VCG(5025),VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3U(24,2),AI(144),AF(144),AMM(24),ALMC(24),S(24),NAME(40),ICS(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1[illegible]
      COMMON/INTCOM/LMP,LM,NLM,LMM,N,NY,NDIM,NSPH,LMIPC,LMT,LMIPCS,
     1[illegible],MXS,MAX
      COMPLEX*16 CC,CSUM,CSS,CCI,CFUN
      DATA PI4/12.566370614356/
      CC=(0.0D0,0.0D0)
      CLP=CC
      CO=0.0D0
      IF(RXX(N2).EQ.CO.AND.RYY(N2).EQ.CO.AND.RZZ(N2).EQ.CO) RETURN
      CCI=(0.0D0,1.0D0)
      L1MO=L1-1
      L1PO=L1+1
      LMINPC=IABS(L2-L1MO)+1
      LMAXPC=L2+L1
      CR=PI4*(L1+L1MO)*(L1+L1PO)*(L2+L2+1)/L1PC
      CC=DSQRT(CR)*CCI
      ISN=1
      IF(L[illegible].GT.L1[illegible].AND.MOD(LMINPC,2).EQ.0) ISN=-ISN
      IF(MOD(M2,2).NE.0) ISN=-ISN
      [illegible]=[illegible]-1
      [illegible]J=[illegible]
      [illegible]Y=[illegible]
      [illegible]J=1,[illegible]
      CSUM=CC
      [illegible]=J-1
      [illegible]1=[illegible]+1
      [illegible]=[illegible]+[illegible]
      IF([illegible]1.LT.-L1MO.OR.MUPM1.GT.L1MO.OR.MUPM2.LT.-L2.OR.MUPM2.GT.L2)
     1GO TO 50
      JSN=ISN
      IND1=INDX([illegible],L1MO,L1,-MU,MUPM1,M1)
      IND2=INDX([illegible],L2,-MU,MUPM2,M2)
      CC=VCG(IND1)*VCG(IND2)
      DO 40 LT=LMINPC,LMAXPC,2
      L3=LT-1
      [illegible]=[illegible]-[illegible]
      IF(MI[illegible]2.LT.-L3.OR.MIMM2.GT.L3) GO TO 40
      NY=L[illegible]+LT+MIMM2
      [illegible]=L[illegible]+LT
      IND3=INDX(L[illegible],L1[illegible],L3,0,0,0)
      IND4=INDX(L2,L1MO,L3,MUPM2,-MUPM1,M2-M1)
      CFUN=JSN*VJ([illegible]J+LT)*VYJ(N[illegible]Y+NY)*VCG(IND3)*VCG(IND4)/DSQRT(ACRS)
      IF(MOD(L3,2).NE.0) CFUN=-CFUN
      CSUM=CSUM+CFUN
   40 JSN=-JSN
      CSUM=CSUM*C[illegible]
      IF([illegible].[illegible].[illegible]) CSUM=-CSUM
   50 CLP=CLP+CSUM
      CLP=CLP*CC
      RETURN
      END
```

```
(MAY 1983)                  VS FORTRAN              DATE  1984 NOV 07      TIME  17 : 16

EFFECT    NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED
         OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(35)

    *....*...1.........2.........3.........4.........5.........6.........7.*...

           FUNCTION NCOC(N1,N2,N)
           IF(N1.GT.N2) GO TO 20
           NF=N1
           NS=N2
           ISN=0
           GO TO 30
        20 NF=N2
           NS=N1
           ISN=1
        30 NCOC=NS-NF
           NFM1=NF-1
           IF(NFM2.LT.1) GO TO 50
           JSUM=0
           DO 40 I=1,NFM2
        40 JSUM=JSUM+I
           NCOC=NCOC+(NFM1)*N-JSUM
        50 IF(ISN.EQ.1) NCOC=-NCOC
           RETURN
           END
```

```
AY 1983)                  VS FORTRAN               DATE   1984 NOV 07      TIME   17 5[illegible] 17

ECK    NOLIST    MAP NOXREF   NOGOSTMT NODECK   SOURCE    TERM    OBJECT FIXED  NOT
        OPT(0) LANGLVL(77) NOFIPS    FLAG(I)   NAME(MAIN   )  LINECOUNT(55)

*....*...1.........2.........3.........4.........5.........6.........7.*...

      FUNCTION INO(L1,L2,L3,M1,M2,M3)
      COMMON/INTCOM/LMAX,LM,NLM,NLMX,NATOM,NDIM,NSPH,LMTPC,LMT,LMTPLS,
     1[illegible],NMX,NMAS,NMAX
      N1=L1*(L1+1)+M1+1
      N2=L2*(L2+1)+M2+1
      N3=L3*(L3+1)+M3+1
      INO=N1+[illegible]*N2+[illegible]3*N3-NMXM
      RETURN
      END
```

```
[illegible]   NOLIST  NOMAP NOXREF  GOSTMT NODECK  SOURCE  TERM  OBJECT FIXED [illegible]
          OPT(0) LANGLVL(66) NOFIPS  FLAG(I)  NAME(MAIN  )  LINECOUNT(55)

*....*...1.........2.........3.........4.........5.........6.........7.*...

      REAL FUNCTION CLEBSF(JA,JB,JC,MA,MB,MC)
      IMPLICIT REAL*8(A-H,O-Z)
      C[illegible] /[illegible]/FACTL(40),[illegible](45)
      IF(MA-[illegible]
 2    CLEBSF=[illegible]
      [illegible]
 4    [illegible]
 5    CLEBSF=[illegible]
      [illegible]
 6    [illegible]
 7    [illegible]
      [illegible]
 8    IF([illegible]
 9    CLEBSF=[illegible]
      [illegible]
 10   IF([illegible]-JC)1[illegible],10,11
 11   [illegible]
      [illegible]
 12   IF(MC+J[illegible])13,1[illegible],14
 13   CLEBSF=[illegible]
      [illegible]
 14   IF(JC-JA-J[illegible])1[illegible],1[illegible],1[illegible]
 15   [illegible]
      [illegible]
 16   JJ1=JA+J[illegible]-JC+1
      JJ2=J[illegible]+JA-J[illegible]+1
      JJ3=J[illegible]-J[illegible]+J[illegible]+1
      JJ4=JC+J[illegible]+J[illegible]+[illegible]
      JJ5=J[illegible]+[illegible]+1
      JJ[illegible]=J[illegible]-[illegible]+1
      JJ7=J[illegible]+[illegible]+1
      JJ[illegible]=J[illegible]-[illegible]+1
      JJ[illegible]=J[illegible]+[illegible]+1
      JJ1[illegible]=J[illegible]-[illegible]+1
      JJ17=-J[illegible]+J[illegible]-[illegible]
      JJ1[illegible]=-J[illegible]+J[illegible]+[illegible]
      JJ1[illegible]=J[illegible]+J[illegible]-J[illegible]
      JJ[illegible]=J[illegible]-M[illegible]
      JJ[illegible]=J[illegible]+[illegible]
      IF(JJ1[illegible]
 17   IF(JJ1[illegible])1[illegible],1[illegible],1[illegible]
 1[illegible]   [illegible]=[illegible]
      [illegible]
 1[illegible]   [illegible]=JJ1[illegible]
      [illegible]
      IF(JJ1[illegible])[illegible]
 [illegible]1  [illegible]=JJ1[illegible]
      [illegible]
 [illegible]   IF(JJ17-JJ1[illegible])1[illegible],19,21
 [illegible]   IF(JJ[illegible]1-JJ19)[illegible],[illegible],2[illegible]
 24   IF(JJ1[illegible]-JJ[illegible])[illegible],2[illegible],27
 [illegible]   [illegible]=JJ21
      [illegible]
 26   [illegible]=JJ1[illegible]
      [illegible]
 27   IF(JJ[illegible]-JJ[illegible])[illegible],2[illegible],2[illegible]
 [illegible]   [illegible]=JJ[illegible]
 [illegible]   S[illegible]=0.
      I=[illegible]
      I[illegible](I-2*(I/2))31,[illegible],31
 [illegible]   [illegible]Y=1.[illegible]
      [illegible]
 31   [illegible]Y=-1.[illegible]
 [illegible]   JJ11=I+1
      JJ12=J[illegible]-I-[illegible]
      JJ1[illegible]=J[illegible]-[illegible]
      JJ14=JJ[illegible]-[illegible]
      JJ1[illegible]=J[illegible]-[illegible]+[illegible]+I+1
      JJ1[illegible]=J[illegible]-J[illegible]-[illegible]+I+1
      [illegible]=FACTL(JJ11)*FACTL(JJ12)*FACTL(JJ13)
     1*FACTL(JJ14)*FACTL(JJ15)*FACTL(JJ16)
      S[illegible]=S[illegible]+[illegible]Y/[illegible]
      IF(I-[illegible])33,34,34
 33   I=I+1
      [illegible]Y=-[illegible]Y
      GO TO [illegible]
 34   A[illegible]=2*JC+1
      S[illegible]1=A[illegible]*FACTL(JJ1)*FACTL(JJ2)*FACTL(JJ3)
```

```
.3....+...1.........2.........3.........4.........5.........6.........7..

      SQUA 3=FACTO (JJ4)
      SQUA 2=FACTO (JJ5)*FACTO (JJ6)*FACTO (JJ7)
     1*FACTO (JJ8)*FACTO (JJ9)*FACTO (JJ10)
      SQUA 4=SQUA 1*SQUA 3/SQUA 2
      CLEB=SQ*DSQRT(SQUA 4)
 35   RETURN
      END
```

```
IT   NOLIST   MAP NOXREF   SOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  N
   OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(:5)

....*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE [illegible](X,N,JCN,FJ)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION FJ(1[illegible])
      I[illegible]=JCN
      IF(X-1.0D-6)7,11,11
    7 FJ(1)=1.
      IF([illegible])1[illegible],1[illegible],
    8 [illegible]=[illegible]+1
      [illegible]=[illegible],
    9 FJ([illegible])=0.
      [illegible]
   11 [illegible]=1.[illegible]
      TST=[illegible]LOG(X)+3.
      IF([illegible].-TST)1[illegible],1[illegible],12
   1[illegible] [illegible]=[illegible].
      [illegible]
   1[illegible] [illegible]=TST
   1[illegible] [illegible]=[illegible]
      IF([illegible]-[illegible])1[illegible],15,16
   1[illegible] F[illegible]=[illegible]+[illegible]LTA
      [illegible]
   1[illegible] F[illegible]=[illegible]+[illegible]I[illegible]
   1[illegible] [illegible]=[illegible]+1.
      I[illegible]=[illegible]+
      IF([illegible]-[illegible])[illegible],21,1[illegible]
   [illegible]
   [illegible] FJ([illegible]+1)=[illegible].
      FJ([illegible])=1.[illegible]-[illegible]
      [illegible]
      [illegible]
   [illegible] [illegible]=[illegible]+[illegible].*[illegible])*FJ(N+1)-FJ(N+2)
      IF([illegible]FJ([illegible])-1.[illegible]+[illegible])[illegible],[illegible],33
   [illegible] IF([illegible]-1)[illegible],[illegible],[illegible]
   2[illegible] [illegible]
      [illegible]=[illegible]-[illegible].
      [illegible]
   [illegible] [illegible]-.[illegible])[illegible],[illegible],27
   [illegible] [illegible]
      [illegible]=[illegible]
      [illegible]=[illegible]
      [illegible]=1.-[illegible].*X*X/1[illegible].-X*X/5[illegible].
      [illegible]=FJ([illegible])/[illegible]
      JJ=1
      [illegible]
   27 [illegible]=[illegible]([illegible])
      IF([illegible]([illegible])-.1)[illegible],[illegible],[illegible]
   [illegible] IF([illegible]-.[illegible])[illegible],[illegible],[illegible]
   [illegible] [illegible]=[illegible]FJ(1)/[illegible]
      JJ=1
      [illegible]
   [illegible] [illegible]=[illegible]FJ([illegible])/[illegible]
      FJ(1)=FJ(1)/[illegible]
      [illegible]=X*[illegible]J([illegible])/([illegible]/X-DCOS(X))
      JJ=[illegible]
   [illegible] [illegible]=[illegible]+1
      [illegible]=JJ,[illegible]
   [illegible] FJ([illegible])=[illegible]/[illegible]
      [illegible]
   [illegible] JJ=[illegible]+1
      [illegible]=JJ,[illegible]
   34 FJ(J)=FJ(J)*1.0D-[illegible]
   [illegible] [illegible]=[illegible]+[illegible]
      [illegible]
      E[illegible]
```

```
  NOLIST   NOMAP NONUMBER   NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NO
   OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(55)

...*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE FN (X,L,FN)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION FN(5)
      IF(X.LT.0.D0.OR.L.LT.0) RETURN
      LP1=L+1
      IF(X.GT.0.D0) GO TO 20
      DO 10 I=1,LP1
   10 FN(I)=-1.0D+50
      RETURN
   20 FN1=-DEXP(-X)/X
      FN2=(FN1-DEXP(-X))/X
      FN(1)=FN1
      FN(2)=FN2
      IF(L.LT.2) RETURN
      XI=1.0D0/X
      LM1=L-1
      DO 30 I=1,LM1
      TIM=I+I+1
      IPI=I+2
      FN0=FN1
      FN1=FN2
      FN2=FN1*XI*TIM-FN0
      FN(IPI)=FN2
   30 CONTINUE
      RETURN
      END
```

```
[illegible])                VS FORTRAN              DATE  1984 NOV 07      TIME  17 [illegible] 2[illegible]

  NOLIST  NOMAP NOXREF  [illegible]  NODECK  SOURCE  TERM  OBJECT FIXED  [illegible]
   OPT([illegible]) LANGLVL([illegible]) NOFIPS  FLAG(I)  NAME(MAIN  )  LINECOUNT(55)

...*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE [illegible](X,N,JCK,FJ)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION FJ(100)
      [illegible] FJ,[illegible],XX,XXXX,XC,S[illegible],CCN,CCNI
      Y=[illegible](X)
      ICK=JCK
      IF(Y-1.D-[illegible])7,11,11
    7 FJ(1)=1.
      IF([illegible])[illegible],1[illegible],[illegible]
      [illegible]=[illegible]+[illegible]
      [illegible]
      [illegible]J([illegible])=[illegible].
      [illegible]
   11 [illegible]=[illegible].[illegible]*Y+[illegible].5
      [illegible]T=4.[illegible](Y)+[illegible].
      IF([illegible].-T[illegible])1[illegible],1[illegible],12
   1[illegible] [illegible]LT[illegible]=[illegible].
      [illegible]T[illegible] 1[illegible]
   1[illegible] [illegible]LT[illegible]=TST
   14 [illegible]=[illegible]
      IF([illegible]-[illegible])1[illegible],15,1[illegible]
   1[illegible] [illegible]=[illegible]+DELTA
      [illegible]T[illegible] 17
   1[illegible] [illegible]=[illegible]+[illegible]LT[illegible]
   17 [illegible]=[illegible]+1.
      I[illegible]=[illegible]+[illegible]
      IF(I[illegible]-JCK)[illegible]1,[illegible]1,1[illegible]
      [illegible]
      FJ([illegible]+1)=[illegible].
      [illegible]=(1.[illegible]-[illegible]/[illegible].1.[illegible]-[illegible])
      [illegible]=[illegible]-1
      [illegible]=[illegible]-1
      [illegible]=([illegible]+[illegible]+[illegible].)/[illegible]*FJ([illegible]+1)-FJ([illegible]+2)
      IF([illegible]J([illegible])-1.[illegible])[illegible],[illegible],[illegible]
      IF([illegible]-1)[illegible],[illegible],[illegible]
   [illegible] [illegible]=[illegible]-1
      [illegible]=[illegible]-1.
      [illegible]
      IF([illegible]-.[illegible])2[illegible],[illegible]7,27
      [illegible]=[illegible]
      X[illegible]=X*[illegible]X
      [illegible]=X[illegible]X
      [illegible]=1.-X[illegible]/6.+[illegible]/120.-X[illegible]/5040.+[illegible].
      [illegible]=[illegible]J(1)/[illegible]
      JJ=1
      [illegible]
   [illegible] [illegible]=[illegible](X)
      IF([illegible]J(S[illegible])-.1)[illegible],[illegible],[illegible]
      IF(Y-.[illegible])[illegible],[illegible],[illegible]
   [illegible] [illegible]=X[illegible]J(1)/[illegible]
      JJ=1
      [illegible]
      [illegible]=X[illegible]FJ(1)/[illegible]
      FJ(1)=FJ(1)/[illegible]
      [illegible]=[illegible]FJ([illegible])/([illegible]/X-[illegible](X))
      JJ=[illegible]
   [illegible] [illegible]=[illegible]+1
      [illegible]=JJ,[illegible]
   [illegible] FJ([illegible])=FJ([illegible])/[illegible]
      [illegible]
   [illegible] JJ=[illegible]+1
      [illegible]=JJ,[illegible]
    [illegible] [illegible]J(J)=FJ(J)*1.D-[illegible]
      [illegible]
      [illegible]
```

```
1)                 VS FORTRAN              DATE  1984 NOV 08      TIME  10 00 48

OLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTE
 OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

...1.........2.........3.........4.........5.........6.........7.*.....

 SUBROUTINE WLM
1(KHELP,TH,PH,LMPC)
 IMPLICIT REAL*8(A-H,O-Z)
 DIMENSION YLM(26)
 COMMON/DUM3/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
1VH(27),VYH(243),VJ(27),VYJ(243)
2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
3W(24,2),AI(144),AF(144),AMMD(24),AEMD(24),S(24),NAME(40),IOG(3)
 COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
1W,AI,AF,AMMD,AEMD,S
 COMMON/DUM5/FACTO(40),FNORM(45)
 COMPLEX*16 YLM,AP,AM,AZ,CL
 DATA PI4/ 12.566370614356/
 NLMP=LMPC*LMPC+1
 YLM(NLMP)=(0.0D0,0.0D0)
 IHELP=1
 IF(KHELP.EQ.2) IHELP=-1
 P=-IHELP
 COST=DCOS(TH)
 SINT=DSIN(TH)
 COSP=DCOS(PH)
 SINP=DSIN(PH)
 CALL SPHAR(COST,SINT,COSP,SINP,LMPC,YLM)
 ALPH1=-COST*COSP
 BETA1=-COST*SINP
 GAM1=SINT
 ALPH2= SINP
 BETA2=-COSP
 GAM2=0.0D0
 AP=.5*(DCMPLX(ALPH1,P*ALPH2)+DCMPLX(BETA1,P*BETA2)*(0.0D0,1.0D0))
 AM=.5*(DCMPLX(ALPH1,P*ALPH2)-DCMPLX(BETA1,P*BETA2)*(0.0D0,1.0D0))
 AZ=DCMPLX(GAM1,P*GAM2)
 DO 20 LF=2,LMPC
 L=LF-1
 LFTL=LF*L
 X=LFTL
 CL=PI4*(0.0D0,1.0D0)**L/DSQRT(X)
 MM=L+LF
 M=-LF
 DO 20 MF=1,MM
 M=M+1
 K=LFTL+M
 X=LFTL-M*(M+1)
 CP=DSQRT(X)
 X=LFTL-M*(M-1)
 CM=DSQRT(X)
 CZ=M
 W(K,KHELP)=DCONJG(AM*CP*YLM(K+2)+AP*CM*YLM(K)+AZ*CZ*YLM(K+1))*CL
 RETURN
 END
```

```
33)               VS FORTRAN            DATE  1984 NOV 08      TIME  10 00 45

NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTE
  OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

.*...1.........2.........3.........4.........5.........6.........7.*.....

      SUBROUTINE SZCT
     1          (IHELP,IEXP,VK,THK,PHK,VCUTN)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUMO/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3A(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),ICG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1A,AI,AF,AMMO,AEMO,S
      COMMON/DUMS/AM(144,144),BV(144),V(144)
      COMPLEX*16 AM,BV
      COMMON/INTCOM/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
     1NSMC,NMX,NMXS,NMXM
      COMPLEX*16 CCC,GIM,GLM,SUM,SSMSP,SSESP,PHAS
      CC=0.0D0
      CCC=(0.0D0,0.0D0)
      IF(IHELP.EQ.1) GO TO 20
      ISA=2
      JSA=1
      GO TO 30
   20 ISA=1
      JSA=2
   30 IF(IEXP.NE.0)GO TO 60
      I1=0
      DO 50 N1=1,NSPH
      DO 50 L1=1,LM
      SSMSP=RM(L1,N1)
      SSESP=SM(L1,N1)
      L1TPC=L1+L1+1
      M1=-L1-1
      DO 50 IM1=1,L1TPC
      M1=M1+1
      I1=I1+1
      SUM=CCC
      I2=0
      DO 45 L2=1,LM
      L2TPC=L2+L2+1
      M2=-L2-1
      DO 45 IM2=1,L2TPC
      M2=M2+1
      I2=I2+1
   45 SUM=SUM+A(I2,ISA)*(GLM(N1,L1,M1,L2,M2)*IHELP+GIM(N1,L1,M1,L2,M2))
      IF(VCUTN.EQ.CC) GO TO 47
      SUR=DREAL(SUM)
      SUI=DIMAG(SUM)
      IF(DABS(SUR).LT.VCUTN)SUR=CC
      IF(DABS(SUI).LT.VCUTN)SUI=CC
      SUM=DCMPLX(SUR,SUI)
   47 V(I1)=-SUM*SSMSP
   50 V(I1+NM)=-SUM*SSESP*IHELP
      RETURN
   60 CKX=VK*DSIN(THK)*DCOS(PHK)
      CKY=VK*DSIN(THK)*DSIN(PHK)
      CKZ=VK*DCOS(THK)
      DO 70 I=1,NSPH
      IJ=(I-1)*NLMM
      PROD=CKX*RXX(I)+CKY*RYY(I)+CKZ*RZZ(I)
      PHAS=CDEXP((0.0,1.0)*PROD)
      K=1
      KTPC=K+K+1
      SSMSP=RM(K,I)
      SSESP=SM(K,I)
      DO 70 J=1,NLMM
      II=IJ+J
      V(II)=-A(J,ISA)*PHAS*SSMSP
      V(II+NM)=-A(J,ISA)*PHAS*SSESP*IHELP
      IF(J.LT.KTPC) GO TO 70
      K=K+1
      KTPC=KTPC+K+K+1
      SSMSP=RM(K,I)
      SSESP=SM(K,I)
   70 CONTINUE
      RETURN
      END
```

```
83)                VS FORTRAN              DATE  1984 NOV 08      TIME  10 00 42

  NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTE
    OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

..*...1.........2.........3.........4.........5.........6.........7.*.....

      SUBROUTINE SMAT
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/JOMO/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3W(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),IGG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1W,AI,AF,AMMO,AEMO,S
      COMMON/CO15/AM(144,144),BV(144),V(144)
      COMPLEX*16 AM,BV
      COMMON/INTCOM/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
     1NSMC,NMX,NMXS,NMAX
      COMPLEX*16 GH,GK,SSMSP,SSESP,COO,CGH,CGK
      COO=(0.0D0,0.0D0)
      I1=0
      DO 30 N1=1,NSPH
      DO 30 L1=1,LM
      SSMSP=RM(L1,N1)
      SSESP=SM(L1,N1)
      L1TPC=L1+L1+1
      M1=-L1-1
      DO 30 IM1=1,L1TPC
      M1=M1+1
      I1=I1+1
      I2=0
      DO 28 N2=1,NSPH
      IF(N2.NE.N1) GO TO 20
      DO 10 J=1,NLMM
      I2=I2+1
      AM(I1,I2)=COO
      AM(I1,I2+NM)=COO
      AM(I1+NM,I2)=COO
   10 AM(I1+NM,I2+NM)=COO
      GO TO 28
   20 RHL=RCOO(N1,N2,NSPH)
      DO 27 L2=1,LM
      L2TPC=L2+L2+1
      M2=-L2-1
      DO 27 IM2=1,L2TPC
      M2=M2+1
      I2=I2+1
      CGH=GH(RHL,L1,M1,L2,M2)
      CGK=GK(RHL,L1,M1,L2,M2)
      AM(I1,I2)=CGH*SSMSP
      AM(I1,I2+NM)=CGK*SSMSP
      AM(I1+NM,I2)=CGK*SSESP
      AM(I1+NM,I2+NM)=CGH*SSESP
   55 FORMAT(3I10,6E15.6)
   27 CONTINUE
   28 CONTINUE
   30 CONTINUE
      RETURN
      END
```

```
   NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTE
     OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

...*...1.........2.........3.........4.........5.........6.........7.*.....

       SUBROUTINE CROSSE
      1(VK,IHELP,
      2SCASEC,ABSSEC,TOTSEC,VCUTA)
       IMPLICIT REAL*8(A-H,O-Z)
       COMMON/JOMO/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
      1VH(27),VYH(243),VJ(27),VYJ(243)
      2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
      3W(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),ICG(3)
       COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
      1W,AI,AF,AMMO,AEMO,S
       COMMON/INTCOM/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
      1NSMC,NMX,NMXS,NMXM
       COMPLEX*16 GIP,GLP,AM,AE,GI,GL,SUMM,SUME,CCO,CCON,OFDET
       C0=0.0D0
       CCO=(0.0D0,0.0D0)
       CK=.5/(VK*VK)
       CCON=-(0.0D0,1.0D0)*(.5*CK/VK)
       IF(IHELP.EQ.-1) GO TO 10
       ISA=1
       JSA=2
       GO TO 12
 10    ISA=2
       JSA=1
 12    I1=0
       DO 20 L1=1,LM
       L1TPC=L1+L1+1
       M1=-L1-1
       DO 20 IM1=1,L1TPC
       M1=M1+1
       I1=I1+1
       I2=0
       SUMM=CCO
       SUME=CCO
       DO 15 N2=1,NSPH
       DO 15 L2=1,LM
       L2TPC=L2+L2+1
       M2=-L2-1
       DO 15 IM2=1,L2TPC
       M2=M2+1
       I2=I2+1
       AM=AF(I2)
       AE=AF(I2+NM)
       GI=GIP(L1,M1,N2,L2,M2)
       GL=GLP(L1,M1,N2,L2,M2)
       SUMM=SUMM+AM*GI+AE*GL
 15    SUME=SUME+AM*GL+AE*GI
       AMMO(I1)=SUMM
 20    AEMO(I1)=SUME
       IF(VCUTA.EQ.C0) GO TO 27
       DO 25 I=1,NLMM
       AMR=DREAL(AMMO(I))
       AMI=DIMAG(AMMO(I))
       AER=DREAL(AEMO(I))
       AEI=DIMAG(AEMO(I))
       IF(DABS(AMR).LT.VCUTA)AMR=C0
       IF(DABS(AMI).LT.VCUTA)AMI=C0
       IF(DABS(AER).LT.VCUTA)AER=C0
       IF(DABS(AEI).LT.VCUTA)AEI=C0
       AMMO(I)=DCMPLX(AMR,AMI)
 25    AEMO(I)=DCMPLX(AER,AEI)
 27    SUMM=CCO
       SUME=CCO
       OFDET=CCO
       DO 30 I=1,NLMM
       AM=AMMO(I)
       AE=AEMO(I)
       GI=DCONJG(AM)
       GL=DCONJG(AE)
       SUMM=SUMM+GI*AM+GL*AE
       OFDET=OFDET+DCONJG(W(I,JSA))*(AM-IHELP*AE)
 30    SUME=SUME+DCONJG(W(I,ISA))*(AM+IHELP*AE)
       SCASEC=CK*DREAL(SUMM)
       TOTSEC=-CK*DREAL(SUME)
       ABSSEC=TOTSEC-SCASEC
       SAC(ISA,ISA)=SUME*CCON
       SAC(JSA,ISA)=OFDET*CCON
```

```
      IF(JIN.EQ.1) GO TO 335
      DO 330 I=1,NLMM
0     S(I)=AEMD(I)
      GO TO 285
5     DO 340 I=1,NLMM
      II=I+IN
      S(I)=AF(II+NM)
      GO TO 285
0     IN=IN+NLMM
5     WRITE(IW,6030)
      IF(JIN.EQ.NSPH) GO TO 370
0     JIN=NSPH
      GO TO 260
0     SCARAT=SCASEC/SCS
      IF(ICOI.NE.1) GO TO 380
      ABSRAT=1.0D0
      GO TO 385
0     ABSRAT=ABSSEC/ACS
5     TOTRAT=TOTSEC/TCS
      QSCA=SCASEC/GCS
      QABS=ABSSEC/GCS
      QTOT=TOTSEC/GCS
      IF(NHELP.EQ.1) TSAS(ISA,ISA)=TSAS(JSA,JSA)
      REFINR=DREAL(SAC(ISA,ISA))/DREAL(TSAS(ISA,ISA))
      ABSOFR=DIMAG(SAC(ISA,ISA))/DIMAG(TSAS(ISA,ISA))
      WRITE(IW,6100)SCASEC,ABSSEC,TOTSEC
      WRITE(IW,6200)SCARAT,ABSRAT,TOTRAT
      WRITE(IW,6400)QSCA,QABS,QTOT
      WRITE(IW,6700)ISA,ISA,SAC(ISA,ISA),JSA,ISA,SAC(JSA,ISA)
      WRITE(IW,6800)ISA,ISA,REFINR,ISA,ISA,ABSOFR
      IF(NHELP.NE.1) GO TO 360
      RDIFF=(DREAL(SAC(JSA,JSA))-DREAL(SAC(ISA,ISA)))/DREAL(SAC(JSA,JS
     1A))
      ADIFF=(DIMAG(SAC(JSA,JSA))-DIMAG(SAC(ISA,ISA)))/DIMAG(SAC(JSA,JSA
     1))
      WRITE(IW,6900)JSA,ISA,RDIFF,JSA,ISA,ADIFF
0     CONTINUE
0     STOP
      END
  [illegible]          27 - 20[illegible]
```

```
5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80

 3  ITER=-1
    DO 145 K=1,NDIM
 5  AI(K)=BV(K)
    IF(VOUTM.EQ.C0) GO TO 170
 7  DO 140 I=1,NDIM
    DO 140 J=1,NDIM
    AMR=DREAL(AM(I,J))
    AMI=DIMAG(AM(I,J))
    IF(DABS(AMR).LT.VOUTM)AMR=C0
    IF(DABS(AMI).LT.VOUTM)AMI=C0
 0  AM(I,J)=DCMPLX(AMR,AMI)
    GO TO 17[illegible]
 0  DO 1[illegible] K=1,NDIM
    AI(K)=AI(K)*CI+AF(K)*CF
 7  IF(VOUTA.EQ.C0) GO TO 173
    DO 172 I=1,NDIM
    AIR=DREAL(AI(I))
    AII=DIMAG(AI(I))
    IF(DABS(AIR).LT.VOUTA)AIR=C0
    IF(DABS(AII).LT.VOUTA)AII=C0
 7  AI(I)=DCMPLX(AIR,AII)
 7  DO 1[illegible] I=1,NDIM
    DET= V(I)
    DO 1[illegible] J=1,NDIM
    DET=DET-AM(I,J)*AI(J)
    IF(VOUTA.EQ.C0) GO TO 1[illegible]
    DETR=DREAL(DET)
    DETI=DIMAG(DET)
    IF(DABS(DETR).LT.VOUTA)DETR=C0
    IF(DABS(DETI).LT.VOUTA)DETI=C0
    DET=DCMPLX(DETR,DETI)
    [illegible](I)=DET
    ITER=ITER+1
    IF([illegible]
    CALL [illegible](VK,IHELP,SCASEC,[illegible],T[illegible]TSEC,VOUTA)
    [illegible]=T[illegible]TSEC
    IF([illegible]) GO TO 15[illegible]
    DELTA=[illegible]SEC/SEC-1.[illegible]
    IF([illegible])WRITE(IW,[illegible])ITER,[illegible]SEC,SEC,DELTA
    IF(DABS(DELTA).LT.TOL)GO TO [illegible]
    IF(ITER.GT.MAXIT)GO TO 15[illegible]
    IF([illegible]) CALL SMAT
    [illegible]I=1,[illegible]
    [illegible](I,I)=[illegible](I,I)+1.[illegible]
    CALL [illegible],V,[illegible],IER,VOUTA)
    IF([illegible].1) GO TO [illegible]
    DO [illegible] I=1,NDIM
    DET=[illegible]
    DO [illegible] J=1,[illegible]
    DET=DET+[illegible](I,J)*BV(J)
    [illegible](I)=DET
    CALL [illegible](VK,IHELP,SCASEC,[illegible],T[illegible]TSEC,VOUTA)
    WRITE(IW,[illegible])NAME
    [illegible]
    IF([illegible])[illegible],[illegible],[illegible]
    J[illegible]=1
    [illegible]=J[illegible],[illegible]
    [illegible]
    IF([illegible].1) GO TO [illegible]
    [illegible] I=1,[illegible]
 7  [illegible](I)=[illegible](I)
 7  [illegible] I=1,[illegible]
    [illegible]
    [illegible](II)
    [illegible](IW,[illegible])
    IF([illegible]) GO TO [illegible]
    [illegible](IW,[illegible])
    [illegible]
    [illegible](IW,[illegible])
    [illegible](IW,[illegible])
    IF([illegible].1) GO TO [illegible]
    [illegible](IW,[illegible])
    [illegible]
    [illegible](IW,[illegible]))
    [illegible](I),I=1,[illegible]
```

```
[illegible]
[illegible] GO TO 125
[illegible]
142 CALL [illegible](IM[illegible],IEXP,VK,IMR,[illegible],VOUT)
      IF(IVER.[illegible]) GO TO [illegible]
      IF(I[illegible]P.[illegible]) GO TO 14[illegible]
      WRITE(IW,[illegible])
      WRITE(IW,[illegible])T[illegible],MAXIT,[illegible]
```

```
      IMPLICIT REAL*8(A-H,O-Z)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CCC                                                                  CCC
CCC                            PRG3                                  CCC
CCC                                                                  CCC
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      [illegible] / [illegible] / XXX(3),YYY(3),ZZZ(3),RCS(3),CRI(3),
     1[illegible](   [illegible]),V(17),VYY(243),VJ(17),VYJ(243)
     2,[illegible],SP(4,4),TCAS(2,2),SAC(2,2),
     [illegible](  ,2),[illegible](144),[illegible](144),[illegible](144),[illegible](24),S(24),NAME(4),I[illegible]
     [illegible],TH,VYJ,[illegible],TCAS,SAC,
     [illegible],[illegible],[illegible],[illegible])
      [illegible]/[illegible]/[illegible](144,144),[illegible](144),[illegible](144)
      [illegible] [illegible],[illegible]
      [illegible]/[illegible]/[illegible](40),[illegible](4)
      [illegible]/[illegible]/[illegible],[illegible],[illegible],[illegible],[illegible],NSPH,LMTPS,[illegible],LMTP[illegible],
     1[illegible],[illegible],[illegible]
      [illegible] [illegible],[illegible],[illegible],[illegible]
      [illegible] PI/3.14159265358979/
 [illegible]  FORMAT(4I2)
 5[illegible] FORMAT(3D[illegible])
 [illegible]  FORMAT([illegible],D[illegible]1.4)
 [illegible]  FORMAT(2I5)
 5[illegible] FORMAT([illegible])
 [illegible]  FORMAT([illegible])
 [illegible]  FORMAT([illegible])
 [illegible]  FORMAT(1H1,////,[illegible],2[illegible]X,[illegible]A4,/,1H ,2[illegible]X,20A4,///)
 [illegible]  FORMAT(1H1,1[illegible]X,'CALCULATIONS [illegible] REFER TO DATASET ',[illegible]A4,///)
 [illegible]  FORMAT(1H ,2[illegible]X,[illegible]AMPLITUDES OF [illegible])
 [illegible]  FORMAT(1H ,[illegible],[illegible]AS[illegible])
 [illegible]  FORMAT(1H ,[illegible],[illegible] MULTIPOLES [illegible])
 [illegible]  FORMAT(1H ,[illegible],[illegible],I2,/)
 [illegible]  FORMAT(4([illegible],D[illegible].7))
 [illegible]  FORMAT(1H ,/)
 [illegible]  FORMAT(1H ,[illegible],[illegible]ELECTRIC)
 [illegible]  FORMAT(1H ,//)
 [illegible]  FORMAT(1H ,[illegible],[illegible]MAGNETIC,/)
 [illegible]  FORMAT(1H ,[illegible],7HSCASEC=,D15.7,[illegible]X,7HABSSEC=,D15.7,5X,7HTOTSEC=,
     1D1[illegible].7,//)
 [illegible]  FORMAT(1H ,[illegible],'CROSS SECTIONS OF SPHERE ',I2,/)
 [illegible]  FORMAT(1H ,[illegible],7HSCARAT=,D15.7,[illegible]X,7HABSRAT=,D15.7,3X,7HTOTRAT=,
     1D1[illegible].7,//)
 [illegible]  FORMAT(1H ,[illegible],7H[illegible]SCAS=,D15.7,[illegible]X,7H[illegible]ABSS=,D15.7,8X,7H[illegible]TOTS=,
     1D1[illegible].7,//)
 [illegible]  FORMAT(1H ,[illegible],'ITER [illegible]                 [illegible]             NWSEC
     1 [illegible]                  ( [illegible]=',D1[illegible].3,', MAXIT=',I2,', CI=',D1[illegible].3,1[illegible]),//)
 [illegible]  FORMAT(1H ,I[illegible],I[illegible],[illegible])
 6[illegible] FORMAT(1H ,1[illegible]X,[illegible]([illegible]X,[illegible]I1,[illegible]X,[illegible]))
 [illegible]  FORMAT(1H ,1[illegible]X,[illegible]([illegible]X,[illegible]I1,5X,D[illegible]))
      I[illegible]=[illegible]
      I[illegible]=[illegible]
      READ(I[illegible],[illegible])IDATA,JDATA,KDATA
      [illegible](I[illegible],[illegible])
      WRITE(I[illegible],[illegible])IDATA,JDATA,KDATA
      READ(I[illegible],[illegible])[illegible]
      DO [illegible] JCAL=1,[illegible]
      READ(I[illegible],[illegible])[illegible]
      READ(I[illegible],[illegible])JCC,IWR[illegible],I[illegible]CSS,I[illegible]CIP
CCC
CCC   T[illegible] START [illegible] CHANGE [illegible] SET JCC=1.
CCC   T[illegible] CHANGE [illegible] SET JCC=2.
CCC   TO CHANGE [illegible] OR [illegible] SET JCC=3.
CCC   T[illegible] CHANGE INTERP [illegible] TH[illegible] OR PH[illegible] SET JCC=4.
CCC
CCC   IF [illegible] [illegible] MULTIPOLAR EXPANSION COEFFICIENT IS WRITTEN
CCC
CCC   IF [illegible] MULTIPOLAR EXPANSION COEFFICIENTS
CCC   A[illegible] [illegible] SITES ARE ALSO WRITTEN.
CCC
CCC   IF I[illegible]CSS=1 CROSS SECTIONS OF THE SINGLE SPHERES ARE WRITTEN.
CCC
CCC   IF I[illegible]CIP=1 DATA ABOUT CONVERGENCE OF ITERATIVE
CCC   [illegible] ARE WRITTEN.
CCC
      IF(JC[illegible].GT.4) GO TO [illegible]
      READ(IR,5[illegible])NSPH,LMPC,IHELP,IEXP,MAXIT,NFAC,JCK,JCL
      READ(IR,5[illegible])(XXX(I),YYY(I),ZZZ(I),I=1,NSPH)
      READ(IR,5[illegible])(ICS(I),I=1,NSPH)
      READ(IR,5[illegible])(RCS(I),I=1,NSPH)
      READ(IR,[illegible]30)(CRI(I),I=1,NSPH)
```

```
.0 (MAY 1983)                VS FORTRAN              DATE  1984 NOV 07      TIME  17       34
N EFFECT     NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM    OBJECT FIXED
              OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(55)

      *....*...1.........2.........3.........4.........5.........6.........7.*..

  1             COMPLEX FUNCTION CDOT*16(Z,A,B,N,ISTEP)
  2             COMPLEX*16 Z,A(1),B(1)
  3             CDOT=Z
  4             IF(N) 4,4,2
  5       2     DO 3 J=1,N
  6       3     CDOT=CDOT+A(1+(J-1)*ISTEP)*B(J)
  7       4     RETURN
  8             END
```

```
      *....*...1.........2.........3.........4.........5.........6.........7.
            AM(I,KCOL)=CTEMP
      4319  CONTINUE
      4309  CONTINUE
            GO TO 6000
      5200  IER=1
            RETURN
      6000  IF(VCUT.LE.0.0D0) RETURN
            CZ=(0.0D0,0.0D0)
            Z=0.0D0
            ICUT=0
            DO 6260 I=1,N
            DO 6260 J=1,N
            DET=AM(I,J)
            AMR=DREAL(DET)
            AMI=DIMAG(DET)
            IF(AMR.EQ.0D0.AND.AMI.EQ.0D0) GO TO 6260
            IF(AMR.EQ.0D0.OR.DABS(AMR).GT.VCUT) GO TO 6250
            AMR=0D0
            ICUT=ICUT+1
      6250  IF(AMI.EQ.0D0.OR.DABS(AMI).GT.VCUT) GO TO 6255
            AMI=0D0
            ICUT=ICUT+1
      6255  AM(I,J)=DCMPLX(AMR,AMI)
      6260  CONTINUE
            RETURN
            END
```

```
  EFFECT   NOLIST   MAP NOXREF   NOGOSTMT NODECK   SOURCE   TERM   OBJECT FIXED
           OPT(0) LANGLVL(66) NOFIPS   FLAG(I)   NAME(MAIN  )   LINECOUNT(55)

    *....*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE CSVINV(AM,V,NDDMST,N,MODE,IER,VDET)
      IMPLICIT COMPLEX*16 (A-H,O-Z)
      DIMENSION AM(NDDMST,1),V(1)
      COMPLEX*16 AM,DET,CDCG,CTEMP,CDOT
      DATA CONST/[illegible]7.27 7*(35D-17/
      IER=0
      [illegible]=-1
      CTEST = ([illegible])**2
 1000 IF( [illegible]) GO TO 1000
      DET=[illegible]
      IF( [illegible] )+ [illegible](DIMAG(DET)) .EQ. 0.0D0) GO TO 5200
      V(1,1) = (1.0D0 ,0.0D0)/DET
      [illegible]
 1009 DO 1009 I=1,N
      [illegible]
      DO 1001 J=1,N
      SUM = SUM +DREAL(AM(I,J))**2 +DIMAG(AM(I,J))**2
 1001 CONTINUE
      V(I)=1.0D0/SUM
 1009 CONTINUE
      DET=1.0D0
      DO 2011 K=1,N
      KPLUS=K+1
      KMINUS=K-1
      L=K
      [illegible]=0.0D0
      DO 2009 I=K,N
      CTEMP = -CDOT(-AM(I,K),AM(I,1),AM(1,K),KMINUS,NDDMST)
      AM(I,K)=CTEMP
      P[illegible] = V(I)*(DREAL(CTEMP)**2 +DIMAG(CTEMP)**2 )
      IF(P[illegible]) GO TO 2009
      [illegible]=P[illegible]
      L=I
 2009 CONTINUE
      VTEMP=V(K)
      IF(L.EQ.K) GO TO 2011
      DO [illegible] J=1,N
      CTEMP =AM(K,J)
      AM(K,J)=AM(L,J)
      AM(L,J)=CTEMP
 [illegible] CONTINUE
      VTEMP=V(L)
      V(L)=V(K)
      DET=-DET
 2011 DET = AM(K,K)*DET
      IF(MODE.NE.0) DET=DSQRT(VTEMP)*DET
      V(K)=L
      IF(PSQMAX.LT.CTEST) GO TO 5200
      CTEMP = 1.0D0/AM(K,K)
      AM(K,K)=CTEMP
      IF(KPLUS.GT.N) GO TO 2019
      DO 2019 J=KPLUS,N
      AM(K,J) = -CTEMP*CDOT(-AM(K,J),AM(K,1),AM(1,J),KMINUS,NDDMST)
 2019 CONTINUE
 2011 CONTINUE
      DO 4110 K=1,NMINUS
      KPLUS=K+1
      DO 4110 I=KPLUS,N
      AM(I,K) = -AM(I,I)*CDOT((0.0D0,0.0D0),AM(I,K),AM(K,K),I-K,
     1NDDMST)
      AM(K,I) = -CDOT(AM(K,I),AM(K,KPLUS),AM(KPLUS,I),I-K-1,NDDMST)
 4110 CONTINUE
 4111 CONTINUE
      DO [illegible] K=1,N
      DO [illegible] I=1,N
      IF(I.GT.K) GO TO 4212
      AM(I,K) = CDOT((0.0D0,0.0D0),AM(I,K),AM(K,K),N-K+1,NDDMST)
      GO TO [illegible]
 4212 AM(I,K) = CDOT(AM(I,K),AM(I,I+1),AM(I+1,K),N-I,NDDMST)
 [illegible] CONTINUE
 [illegible] CONTINUE
      DO 4309 L=1,N
      K=N-L+1
      KCOL=IDINT(V(K))
      IF(KCOL.EQ.K) GO TO 4309
      DO 4310 I=1,N
      CTEMP=AM(I,K)
      AM(I,K)=AM(I,KCOL)
```

```
 .....*...1.........2.........3.........4.........5.........6.........7.*....
               PLMRS(J)=(B*X*PLMRS(K)-C*PLMRS(M))/A
               IF(L-LM)30,31,31
       30      L=L+1
               GO TO 29
       31      L=3
       32      J=(L*(L+1))/2+2
               C=L-1
               B=2*L-1
               A=L
               K=J-L
               M=J-2*L+1
               PLMRS(J)=(B*X*PLMRS(K)-C*PLMRS(M))/A
               IF(L-LM) 33,34,34
       33      L=L+1
               GO TO 32
       34      L=2
       35      M=1
               LAVE=(L*(L+1))/2+1
       36      J=LAVE+M+1
               K=J-1
               N=K-1
               DMT=M
               A=(2.D0*DMT*X)/Y
               B=(M+L)*(L-M+1)
               PLMRS(J)=A*PLMRS(K)-B*PLMRS(N)
               IF(M+1-L) 37,38,38
       37      M=M+1
               GO TO 36
       38      IF(L-LM) 39,40,40
       39      L=L+1
               GO TO 35
       40      [illegible]
               L=0
       41      J=0
               LAVE=L*(L+1)
               LAVE=LAVE+1
               MAVE=LAVE/2+1
       42      IF(J) 44,43,44
       43      YLMRS(LAVE)=F[illegible](MAVE)*PLMRS(MAVE)
               GO TO 45
       44      JA=MAVE+J
               SAVE=F[illegible](JA)*PLMRS(JA)
               MA=J+1
               IA=LAVE+J
               YLMRS(IA)=SAVE*DCMPLX(COSAMP(MA), SINAMP(MA))
               IF(MOD(J,2).NE.0)YLMRS(IA)=-YLMRS(IA)
               IA=LAVE-J
               YLMRS(IA)=SAVE*DCMPLX(COSAMP(MA),-SINAMP(MA))
       45      IF(J-L) 46,47,47
       46      J=J+1
               GO TO 42
       47      IF(L-LM) 48,49,49
       48      L=L+1
               GO TO 41
       49      CONTINUE
               RETURN
               END
```

```
EFFECT    NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED
        OPT(0) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN   )  LINECOUNT(55)

     *....*...1.........2.........3.........4.........5.........6.........7.*...

      SUBROUTINE SPHAR
     1                  (COSPTH,SINPTH,COSRPH,SINRPH,LMPO,YLJRS)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION SINRMP(9),COSRMP(9),PLMRS(45),YLJRS(81)
      COMMON /JUNK/FACTO(40),FNORM(45)
      COMPLEX*16 YLJRS
      LMAX=LMPO-1
      SINRMP(1)=0.D00
      COSRMP(1)=1.D00
      SINRMP(2)=SINRPH
      COSRMP(2)=COSRPH
      IF(LMPO-2) 8,8,6
    6 DO 7 J=3,LMPO
      K=J-1
      SINRMP(J)=SINRPH*COSRMP(K)+COSRPH*SINRMP(K)
    7 COSRMP(J)=COSRPH*COSRMP(K)-SINRPH*SINRMP(K)
    8 CONTINUE
      X=COSPTH
      XA=DABS(X)
      Y=DABS(SINPTH)
      IF(XA-1.D-6) 9,9,18
    9 L=0
   10 LAVE=(L*(L+1))/2+1
      TAVE=2.D00**L
      M=0
   11 N=L+M
      IF(N-2*(N/2)) 12,13,12
   12 J=LAVE+M
      PLMRS(J)=0.D00
      GO TO 14
   13 IA=N+1
      IB=N/2+1
      JC=(L-M)/2
      IC=JC+1
      J=LAVE+M
      PLMRS(J)=(((-1)**JC)*FACTO(IA))/(TAVE*FACTO(IB)*FACTO(IC))
   14 IF(M-L)15,16,16
   15 M=M+1
      GO TO 11
   16 IF(L-LMAX)17,40,40
   17 L=L+1
      GO TO 10
   18 IF(XA-.99999999D00) 28,19,19
   19 PLMRS(1)=1.D00
      PLMRS(2)=X
      L=2
   20 J=(L*(L+1))/2+1
      A=L
      B=2*L-1
      C=L-1
      K=J-L
      M=J-2*L+1
      PLMRS(J)=(B*X*PLMRS(K)-C*PLMRS(M))/A
      IF(L-LMAX) 21,22,22
   21 L=L+1
      GO TO 20
   22 L=1
   23 M=1
      LAVE=(L*(L+1))/2+1
   24 J=LAVE+M
      PLMRS(J)=0.D00
      IF(M-L)25,26,26
   25 M=M+1
      GO TO 24
   26 IF(L-LMAX) 27,40,40
   27 L=L+1
      GO TO 23
   28 PLMRS(1)=1.D00
      PLMRS(2)=X
      PLMRS(3)=Y
      PLMRS(5)=3.D00*Y*X
      L=2
   29 J=(L*(L+1))/2+1
      A=L
      B=2*L-1
      C=L-1
      K=J-L
      M=J-2*L+1
```

```
 EFFECT    NOLIST   NOMAP NOXREF   NOGOSTMT NODECK   SOURCE   TERM    OBJECT FIXED
          OPT(0) LANGLVL(77) NOFIPS    FLAG(I)  NAME(MAIN  )  LINECOUNT(60)

     -....*...1.........2.........3.........4.........5.........6.........7.*..

              SUBROUTINE POLAR(X,Y,Z,R,CTH,STH,CPH,SPH)
              IMPLICIT REAL*8(A-H,O-Z)
              RHO2=X*X+Y*Y
              IF(RHO2.GT.0.0D0) GO TO 10
              CPH=1.0D0
              SPH=0.0D0
              R=DABS(Z)
              IF(R.GT.0.0D0) GO TO 15
              CTH=1.0D0
              STH=0.0D0
              RETURN
       10     R=DSQRT(RHO2+Z*Z)
              RHO=DSQRT(RHO2)
              CPH=X/RHO
              SPH=Y/RHO
       15     CTH=Z/R
              STH=RHO/R
              RETURN
              END
```

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(MAY 1983)             VS FORTRAN             DATE  1984 NOV 08      TIME  10 00 51

EFFECT     NOLIST    MAP NOXREF   GOSTMT NODECK    SOURCE    TERM    OBJECT FIXED  NOTE
             OPT(0) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN   )  LINECOUNT(85)

    *....*...1.........2.........3.........4.........5.........6.........7.*.....

          SUBROUTINE RSM
         1      (LMPC,NGRMX,VK,JCL)
          IMPLICIT REAL*8(A-H,O-Z)
          COMMON/DUMD/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
         1VH(27),VYH(243),VJ(27),VYJ(243)
         2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
         3W(24,2),AI(144),AF(144),AMMC(24),AEMC(24),S(24),NAME(40),IOG(3)
          COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
         1W,AI,AF,AMMC,AEMC,S
          DIMENSION
         1CFJ(100),FN(7),FJ(100)
          COMPLEX*16 CFJ,CRII,VKN,DCFJ,A,B,C,D
          LM=LMPC-1
          LMPT=LMPC+1
          DO 20 I=1,NGRMX
          IOGI=IOG(I)+1
          IF(IOGI.GT.I) GO TO 6
          IOGI=IOGI-1
          DO 5 L=1,LM
          RM(L,I)=RM(L,IOGI)
        5 SM(L,I)=SM(L,IOGI)
          GO TO 20
        6 VKR=VK*RCS(I)
          CRII=CRI(I)
          VKN=VKR*CRII
          CRII=CRII*CRII
          IF(DIMAG(VKN).EQ.0.0D0) GO TO 7
          CALL CBF(VKN,LMPC,JCL,CFJ,IIR)
          IF(IIR.EQ.0) STOP
          GO TO 9
        7 RVKN=DREAL(VKN)
          CALL RBF(RVKN,LMPC,JCL,FJ,IIR)
          IF(IIR.EQ.1) STOP
          DO 8 J=1,LMPT
        8 CFJ(J)= FJ(J)
        9 CALL RBF(VKR,LMPC,JCL,FJ,IIR)
          IF(IIR.EQ.1) STOP
          CALL RNF(VKR,LMPC,FN)
          DO 20 LD=2,LMPC
          L=LD-1
          E=LD+L
          LDPL=LD+1
          DFN=(L*FN(L)-LD*FN(LDPL))
          DFJ=(L*FJ(L)-LD*FJ(LDPL))
          DCFJ=(L*CFJ(L)-LD*CFJ(LDPL))
          A=CFJ(LD)*(VKR*DFN+FN(LD)*E)
          B=VKN*DCFJ+CFJ(LD)*E
          C=CFJ(LD)*(VKR*DFJ+FJ(LD)*E)
          D=FJ(LD)*B
          B=FN(LD)*D
          RM(L,I)=1.0D0/(1.0D0+(0.0D0,1.0D0)*((A-D)/(C-D)))
          SM(L,I)=1.0D0/(1.0D0+(0.0D0,1.0D0)*((CRII*A-B)/(CRII*C-D)))
       20 CONTINUE
          RETURN
          END
```

```
EFFECT    NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTE
           OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

   *....*...1.........2.........3.........4.........5.........6.........7.*.....

      SUBROUTINE AUXIL
     1(NFAC,JCK,JGC,VK)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION YLM(81),FJ(100),FN(9)
      COMPLEX*16 YLM
      COMMON/DUMD/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3X(24,2),AI(144),AF(144),AMMC(24),AEMC(24),S(24),NAME(40),ICG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1X,AI,AF,AMMC,AEMC,S
      COMMON/DUMB/FACTO(40),FNORM(45)
      COMMON/INTCOM/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
     1NSMC,NMX,NMXS,NMXM
      DATA PI4/ 12.566370614356/
      IF(JGC.NE.1) GO TO 18
      LM=LMPC-1
      NLM=LMPC*LMPC
      NLMM=NLM-1
      N=NSPH*NLM
      NM=N-NSPH
      NDIM=NM+NM
      LMTPC=LMPC+LMPC-1
      LMT=LMTPC-1
      LMTPCS=LMTPC*LMTPC
      NSMC=NSPH-1
      NMX=LM*LMPC+LMPC
      NMXS=NMX*NMX
      NMXM=NMXS+NMX
      FACTO(1)=1.0D0
      DO 10 I=2,NFAC
      A=I-1
   10 FACTO(I)=A*FACTO(I-1)
      DO 15 LF=1,LMTPC
      L=LF-1
      LTPO=LF+L
      DO 15 IM=1,LF
      M=IM-1
      LMM=LF-M
      LPM=LF+M
      K=LF*L/2+IM
      A=LTPO*FACTO(LMM)/FACTO(LPM)
      A=A/PI4
   15 FNORM(K)=DSQRT(A)
   18 IF(JGC.GT.2) RETURN
      IVY=0
      IVHB=0
      DO 30 NF=1,NSMC
      NFPC=NF+1
      DO 30 NS=NFPC,NSPH
      RX=RXX(NS)-RXX(NF)
      RY=RYY(NS)-RYY(NF)
      RZ=RZZ(NS)-RZZ(NF)
      CALL POLAR(RX,RY,RZ,RR,CRTH,SRTH,CRPH,SRPH)
      CALL SPHAR(CRTH,SRTH,CRPH,SRPH,LMTPC,YLM)
      DO 20 IV=1,LMTPCS
      IVT=IV+IVY
   20 VYH(IVT)=DCONJG(YLM(IV))
      IVY=IVY+LMTPCS
      ARG=RR*VK
      CALL RBF(ARG,LMT,JCK,FJ,IIR)
      IF(IIR.EQ.1) STOP
      CALL RNF(ARG,LMT,FN)
      DO 25 IV=1,LMTPC
      IVT=IV+IVHB
   25 VH(IVT)=DCMPLX(FJ(IV),FN(IV))
      IVHB=IVHB+LMTPC
   30 CONTINUE
      IVY=0
      IVHB=0
      C0=0.D0
      DO 55 NF=1,NSPH
      RX=-RXX(NF)
      RY=-RYY(NF)
      RZ=-RZZ(NF)
      IF(RX.EQ.C0.AND.RY.EQ.C0.AND.RZ.EQ.C0) GO TO 50
      CALL POLAR(RX,RY,RZ,RR,CRTH,SRTH,CRPH,SRPH)
```

```
*....*...1.........2.........3.........4.........5.........6.........7.*.....
      DO 40 IV=1,LMTPCS
      IVT=IV+IVY
   40 VYJ(IVT)=DCONJG(YLM(IV))
      ARG=RR*VK
      CALL RBF(ARG,LMT,JCK,FJ,IIR)
      IF(IIR.EQ.1) STOP
      DO 45 IV=1,LMTPC
      IVT=IV+IVH3
   45 VJ(IVT)=FJ(IV)
   50 IVY=IVY+LMTPCS
   55 IVH3=IVH3+LMTPC
      RETURN
      END
```

```
EFFECT   NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTE
          OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN   )  LINECOUNT(85)

  *....*...1.........2.........3.........4.........5.........6.........7.*.....
      COMPLEX FUNCTION GH*16(NBL,L1,M1,L2,M2)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/JOJO/ RXX(3),RYY(3),RZZ(3),ROS(3),CRI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),ISAS(2,2),SAC(2,2),
     3W(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),ICG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,ISAS,SAC,
     1W,AI,AF,AMMO,AEMO,S
      COMMON/INTCOM/LMPO,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPO,LMT,LMTPOS,
     1NSMO,NMX,NMXS,NMXM
      COMPLEX*16 CSUM,CCO,CFUN
      DATA PI4/12.566370614356/
      CCO=(0.0D0,0.0D0)
      GH=CCO
      L1PO=L1+1
      LMINPO=IABS(L2-L1)+1
      LMAXPO=L2+L1PO
      CR=PI4*(L1+L1PO)*(L2+L2+1)
      CCR=DSQRT(CR)
      ISN=1
      IF(L2.GT.L1.AND.MOD(LMINPO,2).EQ.0) ISN=-ISN
      IF(MOD(M2,2).NE.0) ISN=-ISN
      IF(NBL.LT.0) GO TO 22
      NBLMO=NBL-1
      GO TO 23
   22 NBLMO=-NBL-1
   23 NBH=NBLMO*LMTPO
      NBY=NBLMO*LMTPOS
      DO 50 JM=1,3
      CSUM=CCO
      MU=JM-2
      MUPM1=MU+M1
      MUPM2=MU+M2
      IF(MUPM1.LT.-L1.OR.MUPM1.GT.L1.OR.MUPM2.LT.-L2.OR.MUPM2.GT.L2)
     1GO TO 50
      JSN=ISN
      CGC1=CLGC(1,L1,L1,-MU,MUPM1,M1)
      CGC2=CLGC(1,L2,L2,-MU,MUPM2,M2)
      CR=CGC1*CGC2
 5555 FORMAT(3I10,6E15.6)
      DO 40 LT=LMINPO,LMAXPO,2
      L3=LT-1
      M1MM2=M1-M2
      IF(M1MM2.LT.-L3.OR.M1MM2.GT.L3) GO TO 40
      NY=L3*L3+LT+M1MM2
      ACRS=L3+LT
      CGC3=CLGC(L2,L1,L3,0,0,0)
      CGC4=CLGC(L2,L1,L3,MUPM2,-MUPM1,M2-M1)
      CFUN=JSN*VH(NBH+LT)*VYH(NBY+NY)*CGC3*CGC4/DSQRT(ACRS)
      IF(NBL.GT.0) GO TO 35
      IF(MOD(L3,2).NE.0) CFUN=-CFUN
   35 CSUM=CSUM+CFUN
   40 JSN=-JSN
      CSUM=CSUM*CR
      IF(MU.NE.0) CSUM=-CSUM
   50 GH=GH+CSUM
      GH=GH*CCR
      RETURN
      END
```

```
EFFECT     NOLIST     MAP NOXREF    GOSTMT NODECK    SOURCE    TERM     OBJECT FIXED   NOT
              OPT(0) LANGLVL(66) NOFIPS     FLAG(I)   NAME(MAIN    )   LINECOUNT(85)

    *....*...1.........2.........3.........4.........5.........6.........7.*....

      COMPLEX FUNCTION GK*16(NBL,L1,M1,L2,M2)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUM0/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3W(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),IOG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1W,AI,AF,AMMO,AEMO,S
      COMMON/INTCOM/LMPO,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPO,LMT,LMTPOS,
     1NSMO,NMX,NMXS,NMXM
      COMPLEX*16 CCR,CSUM,CCO,CCI,CFUN
      DATA PI4/12.566370614356/
      CCO=(0.0D0,0.0D0)
      CCI=(0.0D0,1.0D0)
      GK=CCO
      L1MO=L1-1
      L1PO=L1+1
      LMINPO=IABS(L2-L1MO)+1
      LMAXPO=L2+L1
      CK=PI4*(L1+L1MO)*(L1+L1PO)*(L2+L2+1)/L1PO
      CCR=DSQRT(CK)*CCI
      ISN=1
      IF(L2.GT.L1MO.AND.MOD(LMINPO,2).EQ.0) ISN=-ISN
      IF(MOD(M2,2).NE.0) ISN=-ISN
      IF(NBL.LT.0) GO TO 22
      NBLMO=NBL-1
      GO TO 23
   22 NBLMO=-NBL-1
   23 NBH=NBLMO*LMTPO
      NBY=NBLMO*LMTPOS
      DO 50 JM=1,3
      CSUM=CCO
      MU=JM-2
      MUPM1=MU+M1
      MUPM2=MU+M2
      IF(MUPM1.LT.-L1MO.OR.MUPM1.GT.L1MO.OR.MUPM2.LT.-L2.OR.MUPM2.GT.L2)
     1GO TO 50
      JSN=ISN
      CGC1=CLGC(1,L1MO,L1,-MU,MUPM1,M1)
      CGC2=CLGC(1,L2,L2,-MU,MUPM2,M2)
      CR=CGC1*CGC2
      DO 40 LT=LMINPO,LMAXPO,2
      L3=LT-1
      M1MM2=M1-M2
      IF(M1MM2.LT.-L3.OR.M1MM2.GT.L3) GO TO 40
      NY=L3*L3+LT+M1MM2
      ACRS=L3+LT
      CGC3=CLGC(L2,L1MO,L3,0,0,0)
      CGC4=CLGC(L2,L1MO,L3,MUPM2,-MUPM1,M2-M1)
      CFUN=JSN*VH(NBH+LT)*VYH(NBY+NY)*CGC3*CGC4/DSQRT(ACRS)
      NNBH=NBH+LT
      NNBY=NBY+NY
      IF(NBL.GT.0) GO TO 35
      IF(MOD(L3,2).NE.0) CFUN=-CFUN
   35 CSUM=CSUM+CFUN
   40 JSN=-JSN
      CSUM=CSUM*CR
      IF(MU.NE.0) CSUM=-CSUM
   50 GK=GK+CSUM
      GK=GK*CCR
      RETURN
      END
```

```
ECT     NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTES
          OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

 *....*...1.........2.........3.........4.........5.........6.........7.*.....

       COMPLEX FUNCTION GIM*16(N1,L1,M1,L2,M2)
       IMPLICIT REAL*8(A-H,O-Z)
       COMMON/DOMO/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
      1VH(27),VYH(243),VJ(27),VYJ(243)
      2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
      3W(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),IOG(3)
       COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
      1W,AI,AF,AMMO,AEMO,S
       COMMON/INTCOM/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
      1NSMD,NMX,NMXS,NMXM
       COMPLEX*16 CSUM,CCO,CFUN
       DATA PI4/12.566370614356/
       CCO=(0.0D0,0.0D0)
       GIM=CCO
       C0=0.0D0
       IF(RXX(N1).EQ.C0.AND.RYY(N1).EQ.C0.AND.RZZ(N1).EQ.C0) GO TO 60
       L1PO=L1+1
       LMINPO=IABS(L2-L1)+1
       LMAXPO=L2+L1PO
       CR=PI4*(L1+L1PO)*(L2+L2+1)
       CCR=DSQRT(CR)
       ISN=1
       IF(L2.GT.L1.AND.MOD(LMINPO,2).EQ.0) ISN=-ISN
       IF(MOD(M2,2).NE.0) ISN=-ISN
       N1MO=N1-1
       NBJ=N1MO*LMTPC
       NBY=N1MO*LMTPCS
       DO 50 JM=1,3
       CSUM=CCO
       MU=JM-2
       MUPM1=MU+M1
       MUPM2=MU+M2
       IF(MUPM1.LT.-L1.OR.MUPM1.GT.L1.OR.MUPM2.LT.-L2.OR.MUPM2.GT.L2)
      1GO TO 50
       JSN=ISN
       CGC1=CLGO(1,L1,L1,-MU,MUPM1,M1)
       CGC2=CLGO(1,L2,L2,-MU,MUPM2,M2)
       CR=CGC1*CGC2
       DO 40 LT=LMINPO,LMAXPO,2
       L3=LT-1
       M1MM2=M1-M2
       IF(M1MM2.LT.-L3.OR.M1MM2.GT.L3) GO TO 40
       NY=L3*L3+LT+M1MM2
       ACRS=L3+LT
       CGC3=CLGO(L2,L1,L3,0,0,0)
       CGC4=CLGO(L2,L1,L3,MUPM2,-MUPM1,M2-M1)
       CFUN=JSN*VJ(NBJ+LT)*VYJ(NBY+NY)*CGC3*CGC4/DSQRT(ACRS)
       CSUM=CSUM+CFUN
   40  JSN=-JSN
       CSUM=CSUM*CR
       IF (MU.NE.0) CSUM=-CSUM
   50  GIM=GIM+CSUM
       GIM=GIM*CCR
       RETURN
   60  IF(L1.EQ.L2.AND.M1.EQ.M2) GIM=(1.0D0,0.0D0)
       RETURN
       END
```

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1983)               VS FORTRAN              DATE  1984 NOV 08       TIME  10 01 05

T    NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTEST
      OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN   )  LINECOUNT(85)          CH

....*...1.........2.........3.........4.........5.........6.........7.*.......

      COMPLEX FUNCTION GLM*16(N1,L1,M1,L2,M2)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUMO/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3W(24,2),AI(144),AF(144),AMMC(24),AEMC(24),S(24),NAME(40),ICG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1W,AI,AF,AMMC,AEMC,S
      COMMON/INTCOM/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
     1NSMC,NMX,NMXS,NMXM
      COMPLEX*16 CCR,CSUM,CCO,CCI,CFUN
      DATA PI4/12.566370614356/
      CCO=(0.0D0,0.0D0)
      GLM=CCO
      CO=0.0D0
      IF(RXX(N1).EQ.CO.AND.RYY(N1).EQ.CO.AND.RZZ(N1).EQ.CO) RETURN
      CCI=(0.0D0,1.0D0)
      L1MO=L1-1
      L1PO=L1+1
      LMINPO=IABS(L2-L1MO)+1
      LMAXPO=L2+L1
      CR=PI4*(L1+L1MO)*(L1+L1PO)*(L2+L2+1)/L1PO
      CCR=DSQRT(CR)*CCI
      ISN=1
      IF(L2.GT.L1MO.AND.MOD(LMINPO,2).EQ.0) ISN=-ISN
      IF(MOD(M2,2).NE.0) ISN=-ISN
      N1MO=N1-1
      N3J=N1MO*LMTPC
      N3Y=N1MO*LMTPCS
      DO 50 JM=1,3
      CSUM=CCO
      MU=JM-2
      MUPM1=MU+M1
      MUPM2=MU+M2
      IF(MUPM1.LT.-L1MO.OR.MUPM1.GT.L1MO.OR.MUPM2.LT.-L2.OR.MUPM2.GT.L2)
     1GO TO 50
      JSN=ISN
      CGC1=CLGC(1,L1MO,L1,-MU,MUPM1,M1)
      CGC2=CLGC(1,L2,L2,-MU,MUPM2,M2)
      CR=CGC1*CGC2
      DO 40 LT=LMINPO,LMAXPO,2
      L3=LT-1
      M1MM2=M1-M2
      IF(M1MM2.LT.-L3.OR.M1MM2.GT.L3) GO TO 40
      NY=L3*L3+LT+M1MM2
      ACRS=L3+LT
      CGC3=CLGC(L2,L1MO,L3,0,0,0)
      CGC4=CLGC(L2,L1MO,L3,MUPM2,-MUPM1,M2-M1)
      CFUN=JSN*VJ(N3J+LT)*VYJ(N3Y+NY)*CGC3*CGC4/DSQRT(ACRS)
      CSUM=CSUM+CFUN
   40 JSN=-JSN
      CSUM=CSUM*CR
      IF(MU.NE.0) CSUM=-CSUM
   50 GLM=GLM+CSUM
      GLM=GLM*CCR
      RETURN
      END
```

```
*....*...1.........2.........3.........4.........5.........6.........7.*......
      COMPLEX FUNCTION GIP*16(L1,M1,N2,L2,M2)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUMD/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3W(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),IOG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1W,AI,AF,AMMO,AEMO,S
      COMMON/INTCOM/LMPC,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPC,LMT,LMTPCS,
     1NSMD,NMX,NMXS,NMXM
      COMPLEX*16 CSUM,CCC,CFUN
      DATA PI4/12.566370614356/
      CCC=(0.0D0,0.0D0)
      GIP=CCC
      C0=0.0D0
      IF(RXX(N2).EQ.C0.AND.RYY(N2).EQ.C0.AND.RZZ(N2).EQ.C0) GO TO 60
      L1PC=L1+1
      LMINPC=IABS(L2-L1)+1
      LMAXPC=L2+L1PC
      CR=PI4*(L1+L1PC)*(L2+L2+1)
      CCR=DSQRT(CR)
      ISN=1
      IF(L2.GT.L1.AND.MOD(LMINPC,2).EQ.0) ISN=-ISN
      IF(MOD(M2,2).NE.0) ISN=-ISN
      N2MO=N2-1
      NBJ=N2MO*LMTPC
      NBY=N2MO*LMTPCS
      DO 50 JM=1,3
      CSUM=CCC
      MU=JM-2
      MUPM1=MU+M1
      MUPM2=MU+M2
      IF(MUPM1.LT.-L1.OR.MUPM1.GT.L1.OR.MUPM2.LT.-L2.OR.MUPM2.GT.L2)
     1GO TO 50
      JSN=ISN
      CGC1=CLGC(1,L1,L1,-MU,MUPM1,M1)
      CGC2=CLGC(1,L2,L2,-MU,MUPM2,M2)
      CR=CGC1*CGC2
      DO 40 LT=LMINPC,LMAXPC,2
      L3=LT-1
      M1MM2=M1-M2
      IF(M1MM2.LT.-L3.OR.M1MM2.GT.L3) GO TO 40
      NY=L3*L3+LT+M1MM2
      ALRS=L3+LT
      CGC3=CLGC(L2,L1,L3,0,0,0)
      CGC4=CLGC(L2,L1,L3,MUPM2,-MUPM1,M2-M1)
      CFUN=JSN*VJ(NBJ+LT)*VYJ(NBY+NY)*CGC3*CGC4/DSQRT(ALRS)
      IF(MOD(L3,2).NE.0) CFUN=-CFUN
      CSUM=CSUM+CFUN
   40 JSN=-JSN
      CSUM=CSUM*CR
      IF (MU.NE.0) CSUM=-CSUM
   50 GIP=GIP+CSUM
      GIP=GIP*CCR
      RETURN
   60 IF(L1.EQ.L2.AND.M1.EQ.M2) GIP=(1.0D0,0.0D0)
      RETURN
      END
```

```
   NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTE
    OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN   )  LINECOUNT(65)

....*...1.........2.........3.........4.........5.........6.........7.*.....

      COMPLEX FUNCTION GLP*16(L1,M1,N2,L2,M2)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/DUMO/ RXX(3),RYY(3),RZZ(3),RCS(3),CRI(3),
     1VH(27),VYH(243),VJ(27),VYJ(243)
     2,RM(4,3),SM(4,3),TSAS(2,2),SAC(2,2),
     3W(24,2),AI(144),AF(144),AMMO(24),AEMO(24),S(24),NAME(40),IGG(3)
      COMPLEX*16 CRI,VH,VYH,VYJ,RM,SM,TSAS,SAC,
     1W,AI,AF,AMMO,AEMO,S
      COMMON/INICOM/LMPO,LM,NLM,NLMM,N,NM,NDIM,NSPH,LMTPO,LMT,LMTPOS,
     1NSMO,NMX,NMXS,NMXM
      COMPLEX*16 CCR,CSUM,CCO,CCI,CFUN
      DATA PI4/12.566370614356/
      CCO=(0.0D0,0.0D0)
      GLP=CCO
      CO=0.0D0
      IF(RXX(N2).EQ.CO.AND.RYY(N2).EQ.CO.AND.RZZ(N2).EQ.CO) RETURN
      CCI=(0.0D0,1.0D0)
      L1MO=L1-1
      L1PO=L1+1
      LMINPO=IABS(L2-L1MO)+1
      LMAXPO=L2+L1
      CR=PI4*(L1+L1MO)*(L1+L1PO)*(L2+L2+1)/L1PO
      CCR=DSQRT(CR)*CCI
      ISN=1
      IF(L2.GT.L1MO.AND.MOD(LMINPO,2).EQ.0) ISN=-ISN
      IF(MOD(M2,2).NE.0) ISN=-ISN
      N2MO=N2-1
      NBJ=N2MO*LMTPO
      NBY=N2MO*LMTPOS
      DO 50 JM=1,3
      CSUM=CCO
      MU=JM-2
      MUPM1=MU+M1
      MUPM2=MU+M2
      IF(MUPM1.LT.-L1MO.OR.MUPM1.GT.L1MO.OR.MUPM2.LT.-L2.OR.MUPM2.GT.L2)
     1GO TO 50
      JSN=ISN
      CGC1=CLGO(1,L1MO,L1,-MU,MUPM1,M1)
      CGC2=CLGO(1,L2,L2,-MU,MUPM2,M2)
      CR=CGC1*CGC2
      DO 40 LT=LMINPO,LMAXPO,2
      L3=LT-1
      M1MM2=M1-M2
      IF(M1MM2.LT.-L3.OR.M1MM2.GT.L3) GO TO 40
      NY=L3*L3+LT+M1MM2
      ACRS=L3+LT
      CGC3=CLGO(L2,L1MO,L3,0,0,0)
      CGC4=CLGO(L2,L1MO,L3,MUPM2,-MUPM1,M2-M1)
      CFUN=JSN*VJ(NBJ+LT)*VYJ(NBY+NY)*CGC3*CGC4/DSQRT(ACRS)
      IF(MOD(L3,2).NE.0) CFUN=-CFUN
      CSUM=CSUM+CFUN
   40 JSN=-JSN
      CSUM=CSUM*CR
      IF(MU.NE.0) CSUM=-CSUM
   50 GLP=GLP+CSUM
      GLP=GLP*CCR
      RETURN
      END
```

```
33)              VS FORTRAN            DATE  1984 NOV 08      TIME  10 01 12
 NOLIST    MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTES
   OPT(0) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN  )  LINECOUNT(65)      C

.*...1.........2.........3.........4.........5.........6.........7.*......

      FUNCTION NCOU(N1,N2,N)
      IF(N1.GT.N2) GO TO 20
      NF=N1
      NS=N2
      ISN=0
      GO TO 30
 20   NF=N2
      NS=N1
      ISN=1
 30   NCOU=NS-NF
      NFMO=NF-1
      IF(NFMO.EQ.0) GO TO 50
      JCOU=0
      DO 40 I=1,NFMO
 40   JCOU=JCOU+I
      NCOU=NCOU+NFMO*N-JCOU
 50   IF(ISN.EQ.1) NCOU=-NCOU
      RETURN
      END
```

```
83)              VS FORTRAN              DATE  1984 NOV 08     TIME  10 01 13

 NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTES
   OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)         (

.*...1.........2.........3.........4.........5.........6.........7.*.....

   REAL FUNCTION CLGC*8(JA,JB,JC,MA,MB,MC)
   IMPLICIT REAL*8(A-H,O-Z)
   COMMON/DUMB/FACTO(40),FNORM(45)
   IF(MA-JA)4,4,3
   CLGC=0.0D0
   GOTO35
   IF(MA+JA)5,6,6
   CLGC=0.0D0
   GOTO35
   IF(MB-JB)8,8,7
   CLGC=0.0D0
   GOTO35
   IF(MB+JB)9,10,10
   CLGC=0.0D0
   GOTO35
   IF(MC-JC)12,12,11
   CLGC=0.0D0
   GOTO35
   IF(MC+JC)13,14,14
   CLGC=0.0D0
   GOTO35
   IF(JC-JA-JB)16,16,15
   CLGC=0.0D0
   GOTO35
   JJ1=JA+JB-JC+1
   JJ2=JC+JA-JB+1
   JJ3=JC-JA+JB+1
   JJ4=JC+JA+JB+2
   JJ5=JA+MA+1
   JJ6=JA-MA+1
   JJ7=JB+MB+1
   JJ8=JB-MB+1
   JJ9=JC+MC+1
   JJ10=JC-MC+1
   JJ17=-JC+JB-MA
   JJ18=-JC+JA+MB
   JJ19=JA+JB-JC
   JJ20=JA-MA
   JJ21=JB+MB
   IF(JJ17)17,17,20
   IF(JJ18)18,18,19
   K=0
   GOTO24
   K=JJ18
   GOTO24
   IF(JJ18)21,21,22
   K=JJ17
   GOTO24
   IF(JJ17-JJ18)19,19,21
   IF(JJ21-JJ19)25,25,26
   IF(JJ19-JJ20)23,23,27
   KK=JJ21
   GOTO29
   KK=JJ19
   GOTO29
   IF(JJ21-JJ20)25,25,28
   KK=JJ20
   SUM=0.
   I=K
   IF(K-2*(K/2))31,30,31
   SGY=1.0D0
   GOTO32
   SGY=-1.0D0
   JJ11=I+1
   JJ12=JJ1-I
   JJ13=JJ6-I
   JJ14=JJ7-I
   JJ15=JC-JB+MA+I+1
   JJ16=JC-JA-MB+I+1
   PRODU =FACTO (JJ11)*FACTO (JJ12)*FACTO (JJ13)
  1*FACTO (JJ14)*FACTO (JJ15)*FACTO (JJ16)
   SUM=SUM+SGY/PRODU
   IF(I-KK)33,34,34
   I=I+1
   SGY=-SGY
   GOTO32
   ARG=2*JC+1
```

```
.*...1.........2.........3.........4.........5.........6.........7.*.....
  SQUA 2=FACTO (JJ4)
  SQUA 3=FACTO (JJ5)*FACTO (JJ6)*FACTO (JJ7)
 1*FACTO (JJ8)*FACTO (JJ9)*FACTO (JJ10)
  SQUA 4=SQUA 1*SQUA 3/SQUA 2
  CLGC=SUM*DSQRT(SQUA 4)
  RETURN
  END
```

```
3)            VS FORTRAN            DATE  1984 NOV 08      TIME  10 01 16

NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTE
  OPT(0) LANGLVL(66) NOFIPS    FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

*...1.........2.........3.........4.........5.........6.........7.*.....

 SUBROUTINE RBF(X,N,JCK,FJ,IIR)
 IMPLICIT REAL*8(A-H,O-Z)
 DIMENSION FJ(100)
 IIR=0
 ICK=JCK
 IF(X-1.0D-6)7,11,11
 FJ(1)=1.
 IF(N)10,10,8
 MM=N+1
 DO 9 M=2,MM
 FJ(M)=0.
 GO TO 35
 FNC=1.04*X+6.5
 TST=+.21*.4342944819*DLOG(X)+3.
 IF(2.-TST)13,12,12
 DELTA=2.
 GO TO 14
 DELTA=TST
 FN=N
 IF(FN-FNC)15,15,16
 FNS=FNC+DELTA
 GO TO 17
 FNS=FN+DELTA
 NS=FNS+1.
 ICK=NS+2
 IF(ICK-JCK)21,21,18
 IIR=1
 RETURN
 FJ(NS+1)=0.
 FJ(NS)=1.0D-45
 M=NS-1
 FM=M-1
 FJ(M)=((FM+FM+3.)/X)*FJ(M+1)-FJ(M+2)
 IF(DABS(FJ(M))-1.0D+40)23,33,33
 IF(M-1)25,25,24
 M=M-1
 FM=FM-1.
 GO TO 22
 IF(X-.02)26,27,27
 XX=X*X
 XXXX=XX*XX
 X6=XXXX*XX
 SER=1.-XX/6.+XXXX/120.-X6/5040.
 CON=FJ(1)/SER
 JJ=1
 GO TO 31
 SER=DSIN(X)
 IF(DABS(SER)-.1)28,29,29
 IF(X-.11)27,29,30
 CON=X*FJ(1)/SER
 JJ=1
 GO TO 31
 CON1=X*FJ(1)/SER
 FJ(1)=FJ(1)/CON1
 CON=X*FJ(2)/(SER/X-DCOS(X))
 JJ=2
 MM=N+1
 DO 32 M=JJ,MM
 FJ(M)=FJ(M)/CON
 GO TO 35
 JJ=M+1
 DO 34 J=JJ,NS
 FJ(J)=FJ(J)*1.0D-45
 GO TO 22
 M=M+1
 RETURN
 END
```

```
           VS FORTRAN           DATE  1984 NOV 08      TIME  10 01 18

LIST    MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTES
OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  ) LINECOUNT(85)       C

..1.........2.........3.........4.........5.........6.........7.*......

UBROUTINE RNF(X,L,FN)
PLICIT REAL*8(A-H,O-Z)
IMENSION FN(9)
F(X.LT.0.0D0.OR.L.LT.0) RETURN
PO=L+1
F(X.GT.0.0D0) GO TO 20
O 10 I=1,LPO
N(I)=-1.0D+50
ETURN
N1=-DCOS(X)/X
N2=(FN1-DSIN(X))/X
N(1)=FN1
N(2)=FN2
F(L.LT.2) RETURN
I=1.0D0/X
MO=L-1
O 30 I=1,LMO
ITPO=I+I+1
PT=I+2
N0=FN1
N1=FN2
N2=FN1*XI*ITPO-FN0
N(IPT)=FN2
ETURN
ND
```

AD-A158 057 THE OPTICAL SPECTRA OF AEROSOLS(U) MESSINA UNIV (ITALY) 2/2
IST DI STRUTTURA DELLA MATERIA F BORGHESE FEB 85
R/D-4103-EN DAJA37-81-C-0895

UNCLASSIFIED FFG 4/1 NL

END
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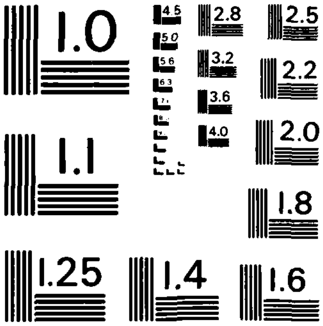

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
N EFFECT     NOLIST    MAP NOXREF   GOSTMT NODECK   SOURCE    TERM    OBJECT FIXED
                OPT(0) LANGLVL(66) NOFIPS      FLAG(I)   NAME(MAIN   )   LINECOUNT(85)

        *....*...1.........2.........3.........4.........5.........6.........7.*...

              SUBROUTINE CBF(X,N,JCK,FJ,IIR)
              IMPLICIT REAL*8(A-H,O-Z)
              DIMENSION FJ(100)
              COMPLEX*16 FJ,X,XX,XXXX,X6,SER,CON,CON1
              IIR=0
              Y=CDABS(X)
              ICK=JCK
              IF(Y-1.0D-8)7,11,11
            7 FJ(1)=1.
              IF(N)10,10,8
            8 MM=N+1
              DO 9 M=2,MM
            9 FJ(M)=0.
           10 RETURN
           11 FNC=1.04*Y+6.5
              TST=4.21*DLOG10(Y)+3.
              IF(2.-TST)13,12,12
           12 DELTA=2.
              GO TO 14
           13 DELTA=TST
           14 FN=N
              IF(FN-FNC)15,15,16
           15 FNS=FNC+DELTA
              GO TO 17
           16 FNS=FN+DELTA
           17 NS=FNS+1.
              ICK=NS+2
              IF(ICK-JCK)21,21,18
           18 IIR=1
              RETURN
           21 FJ(NS+1)=0.
              FJ(NS)=(1.0D-37,1.0D-37)
              M=NS-1
              FM=M-1
           22 FJ(M)=((FM+FM+3.)/X)*FJ(M+1)-FJ(M+2)
              IF(CDABS(FJ(M))-1.0D33)23,33,33
           23 IF(M-1)25,25,24
           24 M=M-1
              FM=FM-1.
              GO TO 22
           25 IF(Y-.02)26,27,27
           26 XX=X*X
              XXXX=XX*XX
              X6=XXXX*XX
              SER=1.-XX/6.+XXXX/120.-X6/5040.
              CON=FJ(1)/SER
              JJ=1
              GO TO 31
           27 SER=CDSIN(X)
              IF(CDABS(SER)-.1)28,29,29
           28 IF(Y-.11)29,29,30
           29 CON=X*FJ(1)/SER
              JJ=1
              GO TO 31
           30 CON1=X*FJ(1)/SER
              FJ(1)=FJ(1)/CON1
              CON=X*FJ(2)/(SER/X-CDCOS(X))
              JJ=2
           31 MM=N+1
              DO 32 M=JJ,MM
           32 FJ(M)=FJ(M)/CON
              RETURN
           33 JJ=M+1
              DO 34 J=JJ,NS
           34 FJ(J)=FJ(J)*1.0D-33
              GO TO 22
              END
```

```
MAY 1983)              VS FORTRAN             DATE  1984 NOV 08      TIME  10 01 21
FECT    NOLIST    MAP NOXREF    GOSTMT NODECK   SOURCE    TERM    OBJECT FIXED  NOTES
          OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)          C

  *....*...1.........2.........3.........4.........5.........6.........7.*......

        SUBROUTINE POLAR(X,Y,Z,R,CTH,STH,CPH,SPH)
        IMPLICIT REAL*8(A-H,O-Z)
        RHO=X*X+Y*Y
        IF(RHO.GT.0.0D0) GO TO 10
        CPH=1.0D0
        SPH=0.0D0
        R=DABS(Z)
        IF(R.GT.0.0D0) GO TO 15
        CTH=1.0D0
        STH=0.0D0
        RETURN
     10 R=DSQRT(RHO+Z*Z)
        RHO=DSQRT(RHO)
        CPH=X/RHO
        SPH=Y/RHO
     15 CTH=Z/R
        STH=RHO/R
        RETURN
        END
```

```
FFECT    NOLIST    MAP NOXREF   GOSTMT NODECK    SOURCE    TERM    OBJECT FIXED  NOTE
           OPT(0) LANGLVL(66) NOFIPS    FLAG(I)   NAME(MAIN   )  LINECOUNT(85)

   *....*...1.........2.........3.........4.........5.........6.........7.*.....

          SUBROUTINE SPHAR
         1                    (COSRTH,SINRTH,COSRPH,SINRPH,LMPO,YLJRS)
          IMPLICIT REAL*8(A-H,O-Z)
          DIMENSION SINRMP(9),COSRMP(9),PLMRS(45),YLJRS(81)
          COMMON/DUMG/FACTO(40),FNORM(45)
          COMPLEX*16 YLJRS
          LM=LMPO-1
          SINRMP(1)=0.0D0
          COSRMP(1)=1.0D0
          SINRMP(2)=SINRPH
          COSRMP(2)=COSRPH
          IF(LMPO-2   )8,8,6
     6    DO 7 J=3,LMPO
          K=J-1
          SINRMP(J)=SINRPH*COSRMP(K)+COSRPH*SINRMP(K)
     7    COSRMP(J)=COSRPH*COSRMP(K)-SINRPH*SINRMP(K)
     8    CONTINUE
          X=COSRTH
          XA=DABS(X)
          Y=DABS(SINRTH)
          IF(XA-1.0D-6) 9,9,18
     9    L=0
    10    LAVE=(L*(L+1))/2+1
          TAVE=2.0D0**L
          M=0
    11    K=L+M
          IF(K-2*(K/2)) 12,13,12
    12    J=LAVE+M
          PLMRS(J)=0.0D0
          GO TO 14
    13    IA=K+1
          IB=K/2+1
          JC=(L-M)/2
          IC=JC+1
          J=LAVE+M
          PLMRS(J)=(((-1)**JC)*FACTO(IA))/(TAVE*FACTO(IB)*FACTO(IC))
    14    IF(M-L)15,16,16
    15    M=M+1
          GO TO 11
    16    IF(L-LM)17,40,40
    17    L=L+1
          GO TO 10
    18    IF(XA-.9999999D0) 28,19,19
    19    PLMRS(1)=1.0D0
          PLMRS(2)=X
          L=2
    20    J=(L*(L+1))/2+1
          A=L
          B=2*L-1
          C=L-1
          K=J-L
          M=J-2*L+1
          PLMRS(J)=(B*X*PLMRS(K)-C*PLMRS(M))/A
          IF(L-LM) 21,22,22
    21    L=L+1
          GO TO 20
    22    L=1
    23    M=1
          LAVE=(L*(L+1))/2+1
    24    J=LAVE+M
          PLMRS(J)=0.0D0
          IF(M-L)25,26,25
    25    M=M+1
          GO TO 24
    26    IF(L-LM) 27,40,40
    27    L=L+1
          GO TO 23
    28    PLMRS(1)=1.0D0
          PLMRS(2)=X
          PLMRS(3)=Y
          PLMRS(5)=3.0D0*Y*X
          L=2
    29    J=(L*(L+1))/2+1
          A=L
          B=2*L-1
          C=L-1
```

```
    *....*...1.........2.........3.........4.........5.........6.........7.*.....
          PLMRS(J)=(B*X*PLMRS(K)-C*PLMRS(M))/A
          IF(L-LM)30,31,31
    30    L=L+1
          GO TO 29
    31    L=3
    32    J=(L*(L+1))/2+2
          A=L-1
          B=2*L-1
          C=L
          K=J-L
          M=J-2*L+1
          PLMRS(J)=(B*X*PLMRS(K)-C*PLMRS(M))/A
          IF(L-LM) 33,34,34
    33    L=L+1
          GO TO 32
    34    L=2
    35    M=1
          LAVE=(L*(L+1))/2+1
    36    J=LAVE+M+1
          K=J-1
          N=K-1
          EAT=M
          A=(2.0D0*EAT*X)/Y
          B=(M+L)*(L-M+1)
          PLMRS(J)=A*PLMRS(K)-B*PLMRS(N)
          IF(M+1-L) 37,38,38
    37    M=M+1
          GO TO 36
    38    IF(L-LM) 39,40,40
    39    L=L+1
          GO TO 35
    40    CONTINUE
          L=0
    41    J=0
          KAVE=L*(L+1)
          LAVE=KAVE+1
          MAVE=KAVE/2+1
    42    IF(J) 44,43,44
    43    YLJRS(LAVE)=FNORM(MAVE)*PLMRS(MAVE)
          GO TO 45
    44    JA=MAVE+J
          SAVE=FNORM(JA)*PLMRS(JA)
          MA=J+1
          IA=LAVE+J
          YLJRS(IA)=SAVE*DCMPLX(COSRMP(MA), SINRMP(MA))
          IF(MOD(J,2).NE.0)YLJRS(IA)=-YLJRS(IA)
          IA=LAVE-J
          YLJRS(IA)=SAVE*DCMPLX(COSRMP(MA),-SINRMP(MA))
    45    IF(J-L) 46,47,47
    46    J=J+1
          GO TO 42
    47    IF(L-LM)48,49,49
    48    L=L+1
          GO TO 41
    49    CONTINUE
          RETURN
          END
```

```
 *....*..1.........2.........3.........4.........5.........6.........7.*.......

      SUBROUTINE CSMINV(AM,V,NDDMST,N,MODE,IER,VCUT)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION AM(NDDMST,1),V(1)
      COMPLEX*16 AM,DET,CSUM,CTEMP,CDOT
      DATA CONST/3.5527136788005D-17/
      IER=0
      NMINUS=N-1
      PTEST = (4.0D0*CONST*N)**2
 1200 IF(N.NE.1) GO TO 1300
      DET=AM(1,1)
      IF( DABS(DREAL(DET))+DABS(DIMAG(DET)) .EQ. 0.0D0) GO TO 5200
      AM(1,1) = (1.0D0,0.0D0)/DET
      RETURN
 1300 DO 1309 I=1,N
      SUM=0.0D0
      DO 1319 J=1,N
      SUM = SUM +DREAL(AM(I,J))**2 +DIMAG(AM(I,J))**2
 1319 CONTINUE
      V(I)=1.0D0/SUM
 1309 CONTINUE
      DET=1.0D0
      DO 2019 K=1,N
      KPLUS=K+1
      KMINUS=K-1
      L=K
      PSQMAX=0.0D0
      DO 2029 I=K,N
      CTEMP = -CDOT(-AM(I,K),AM(I,1),AM(1,K),KMINUS,NDDMST)
      AM(I,K)=CTEMP
      PSQ = V(I)*(DREAL(CTEMP)**2 +DIMAG(CTEMP)**2 )
      IF(PSQ.LE.PSQMAX) GO TO 2029
      PSQMAX=PSQ
      L=I
 2029 CONTINUE
      VTEMP=V(K)
      IF(L.EQ.K) GO TO 2011
      DO 2049 J=1,N
      CTEMP=AM(K,J)
      AM(K,J)=AM(L,J)
      AM(L,J)=CTEMP
 2049 CONTINUE
      VTEMP=V(L)
      V(L)=V(K)
      DET=-DET
 2011 DET = AM(K,K)*DET
      IF(MODE.NE.0) DET=DSQRT(VTEMP)*DET
      V(K)=L
      IF(PSQMAX.LE.PTEST) GO TO 5200
      CTEMP = 1.0D0/AM(K,K)
      AM(K,K)=CTEMP
      IF(KPLUS.GT.N) GO TO 2019
      DO 2059 J=KPLUS,N
      AM(K,J) = -CTEMP*CDOT(-AM(K,J),AM(K,1),AM(1,J),KMINUS,NDDMST)
 2059 CONTINUE
 2019 CONTINUE
      DO 4109 K=1,NMINUS
      KPLUS=K+1
      DO 4119 I=KPLUS,N
      AM(I,K) = -AM(I,I)*CDOT((0.0D0,0.0D0),AM(I,K),AM(K,K),I-K,
     1NDDMST)
      AM(K,I) = -CDOT(AM(K,I),AM(K,KPLUS),AM(KPLUS,I),I-K-1,NDDMST)
 4119 CONTINUE
 4109 CONTINUE
      DO 4209 K=1,N
      DO 4219 I=1,N
      IF(I.GE.K) GO TO 4212
      AM(I,K) = CDOT((0.0D0,0.0D0),AM(I,K),AM(K,K),N-K+1,NDDMST)
      GO TO 4219
 4212 AM(I,K) = CDOT(AM(I,K),AM(I,I+1),AM(I+1,K),N-I,NDDMST)
 4219 CONTINUE
 4209 CONTINUE
      DO 4309 L=1,N
      K=N-L+1
      KCOL=IDINT(V(K))
      IF(KCOL.EQ.K) GO TO 4309
      DO 4319 I=1,N
      CTEMP=AM(I,K)
```

```
 *....*...1.........2.........3.........4.........5.........6.........7.*.....
       AM(I,KCOL)=CTEMP
  4319 CONTINUE
  4309 CONTINUE
       GO TO 6000
  5200 IER=1
       RETURN
  6000 IF(VCUT.EQ.0.0D0) RETURN
       C0D=(0.0D0,0.0D0)
       C0=0.0D0
       ICUT=0
       DO 6260 I=1,N
       DO 6260 J=1,N
       DET=AM(I,J)
       AMR=DREAL(DET)
       AMI=DIMAG(DET)
       IF(AMR.EQ.C0.AND.AMI.EQ.C0) GO TO 6260
       IF(AMR.EQ.C0.OR.DABS(AMR).GT.VCUT) GO TO 6250
       AMR=C0
       ICUT=ICUT+1
  6250 IF(AMI.EQ.C0.OR.DABS(AMI).GT.VCUT) GO TO 6255
       AMI=C0
       ICUT=ICUT+1
  6255 AM(I,J)=DCMPLX(AMR,AMI)
  6260 CONTINUE
       RETURN
       END
```

```
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ECT    NOLIST   MAP NOXREF   GOSTMT NODECK   SOURCE   TERM   OBJECT FIXED  NOTES
         OPT(0) LANGLVL(66) NOFIPS   FLAG(I)  NAME(MAIN  )  LINECOUNT(85)

 *....*...1.........2.........3.........4.........5.........6.........7.*......

       COMPLEX FUNCTION CDOT*16(Z,A,B,N,ISTEP)
       COMPLEX*16 Z,A(1),B(1)
       CDOT=Z
       IF(N) 4,4,2
  2    DO 3 J=1,N
  3    CDOT=CDOT+A(1+(J-1)*ISTEP)*B(J)
  4    RETURN
       END
```

OUTPUT DESCRIPTION

In this section we give the meaning of the output quantities of all the programs.

When IWCSS=1 the programs write the cross sections of each one of the spheres in the cluster:

SCASEC ABSSEC TOTSEC	Scattering, absorption and total cross section for the spheres in the cluster, respectively.
QSCAS QABSS QTOTS	Ratio between the scattering, absorption and total cross section, respectively, and the geometrical cross section of the spheres.

The some quantities are written for the cluster as a whole, so that:

SCASEC ABSSEC TOTSEC	Scattering, absorption and total cross section, respectively, for the cluster.
QSCAS QABSS QTOTS	Ratio between the scattering, absorption and total cross section of the cluster, and the sum of the geometrical cross section of the constituent spheres, respectively.

Furthermore the programs write the following informations relative to the cluster as a whole:

SCARAT ABSRAT TOTRAT	Ratio between the cross sections of the cluster and the sum of the corresponding cross sections of the constituent spheres calculated according to the Mie theory.

The last information written by the programs is marked 11 and 21 if IHELP=+1, and 22, 12 if IHELP=-1.

11 is the 11 component of the normalized forward scattering cross section of the cluster, while 21 is the 21 component of

the same quantity. Analogous meaning have the quantities marked 22 and 12.

Furthermore, 11 also marks the quantities

$$\frac{\mathrm{Re}\ \underline{f}_{\eta\eta}(\mathrm{cluster})}{\mathrm{Re}\sum\underline{f}_{\eta\eta}\ (\mathrm{spheres})} \qquad \text{and} \qquad \frac{\mathrm{Im}\ \underline{f}_{\eta\eta}(\mathrm{cluster})}{\mathrm{Im}\sum\underline{f}_{\eta\eta}\ (\mathrm{spheres})}$$

According to ref.(5) these quantities are related to the macroscopic optical constants of an assembly of clusters with low density.

TABLE I

Number of the elements of the T-matrix (EN) for a cluster of N spheres with a given L_M. The actual memory requirements for this matrix is obtained by multiplying EN by 16. The asterisk marks the entries corresponding to clusters that can be handled by PRG2. All the other entries correspond to clusters that must be handled by PRG3. The maximum capability of PRG3 is a cluster of 70 spheres with L_M=1. This requires to handle a T-matrix with 176400 elements. The total memory requirement of the program is of 4 Mbytes.

	N	L_M	EN
*	4	3	14.400
*		4	36.864
		5	78.400
		6	147.456
*	5	3	22.500
*		4	57.600
		5	122.500
*	6	2	9.216
*		3	32.400
		4	82.944
		5	122.400
*	7	2	12.544
*		3	44.100
		4	112.896
*	8	2	16.384
*		3	57.600
		4	147.456

```
[illegible],CLASS=7,USER='[illegible]7C1,[illegible]'

[illegible]
[illegible],SIZE=AUT[illegible]

[illegible] N=.7,IM=[illegible],PH=[illegible], LV=3
-.7[illegible] , CONTAIT[illegible], NC=1.4,NF=1.5, MODE=3
[illegible]
        [illegible]      0.0              0 00       0.0       0 00
        [illegible]     -0.716571         0 00       0.0       0 00
        [illegible]     -0.716571         0 00       0.0       0 00

        [illegible]      0.0              0 00       0.5       0 00
        [illegible]      0.000            0 00
        [illegible]      0.000            0 00
        [illegible]      0.000            0 00
                     00.0          00.0
        [illegible]      0.1000000[illegible]-05
    1.   [illegible]   1.    0-2[illegible]
[illegible] N=.3,IM=[illegible],PH=[illegible], LV=3
.7[illegible] CONTAITC, NC=1.4,NF=1.5, MODE=3

        [illegible]      0.0              0 00       0.0       0 00
        [illegible]     -0.716571         0 00       0.0       0 00
        [illegible]     -0.716571         0 00       0.0       0 00

        [illegible]      0.0              0 00       0.5       0 00
        [illegible]      0.000            0 00
        [illegible]      0.000            0 00
        [illegible]      0.000            0 00
                     00.0          00.0
        [illegible]      0.10000000-05
    1.   [illegible]   1.    0-2[illegible]

[illegible]           44 RECORDS
```

```
 ...   ....1....2....2....3....3....4....4....5....5....6....    ....7 ...

          TEST,CLASS=7,USER='COC7CI,[illegible]'

        ,    [illegible]=EXT.CL
       [illegible],SIZE=ACTC



  .            0.00      0.0          0.00         0.0          0.00
  1.           0.00     -0.716771     0.00         0.0          0.00
 -1.           0.00     -0.716771     0.00         0.0          0.00

  .7           0.00      0.0          0.00         0.5          0.00
 1.            0.00      0.000        0.00
 1.            0.00      0.000        0.00
 1.            0.00      0.000        0.00
  .7           0.00    00.0         00.0
          14,
  .           0.0        0.1000000D-05
 .   [illegible]  S, K=.7,IH=00,PH=00, LY=3
    .  .  ..5, CONTAIT., N0=1.4,NH=1.5, MODE=3


  .            0.0       0.0          0.00         0.0          0.00
  .            0.00     -0.716771     0.00         0.0          0.00
               0.00     -0.716771     0.00         0.0          0.00

  .            0.00      0.0          0.00         0.5          0.00
  .            0.00      0.0          0.0
  .            0.00      0.0          0.00
  .            0.00      0.000        0.00
  .            0       00.0         00.0
          14,
  .           0.0        0.1000000D-05
 .   [illegible]  A, K=.3,IH=00,PH=00, LY=3
    .  .  ..5, CONTAIT., N0=1.4,NH=1.5, MODE=3


  .                 41 RECORDS
```